APPENDIX F
IN SITU POREWATER SAMPLING STUDY



UPPER COLUMBIA RIVER IN-SITU POREWATER ASSESSMENT SAMPLING AND QUALITY ASSURANCE PLAN

Submitted to
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Acronym List

bgs	below ground surface
CCT	Confederated Tribes of the Colville Reservation
COC	Chain of Custody
DQO	data quality objective
Ecology	Washington State Department of Ecology
EI	Environment International, Ltd.
EPA	United States Environmental Protection Agency
FD	field duplicate
ft	feet
FTWP	Field Task Work Plan
GPS	Global Positioning System
HDPE	high-density polyethylene
HSP	Health and Safety Plan
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectrum
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
IDW	investigation-derived waste
L	Liter
mg/L	milligrams per liter
mL	milliliters
mL/min	milliliters per minute
MS	matrix spike
MSD	matrix spike duplicate
ORP	oxidation reduction potential
Pb	lead
QA	quality assurance
QC	quality control
RL	reporting limit
RM	river mile
RPD	relative percent difference
SOP	standard operating procedure
SQAP	Sampling and Quality Assurance Plan
Study	UCR In-Situ Porewater Assessment
TAL	Target Analyte List
TBD	To Be Determined
TOC	Total Organic Carbon
TCM	Teck Cominco Metals Limited
UCR	Upper Columbia River
USGS	United States Geological Survey

1. APPROVAL PAGE

Document Title: Sampling and Quality Assurance Plan (SQAP) for Upper Columbia River (UCR) In-Situ Porewater Assessment

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2. PROJECT ORGANIZATION

This section provides a brief description of how the project is organized, including identification of the key project personnel and their responsibilities and a flow chart showing the chain of command. **Table 2-1** describes each participant's role in this project.

Table 2-1
Project Personnel Responsibilities

Name	Title	Organizational Affiliation and Contact Info	Responsibilities
Dimitri Vlassopoulos*	Project Officer	Anchor QEA *Phone*: 503.688.5057 ext. 12 *Email*: dvlassopoulos@anchorqua.com	Oversees all project activities, approval of the SQAP and all project modifications.
Whitney Fraser*	Project Manager	Environment International *Phone*: 206.525.3362 *Email*: Whitney.Fraser@eiltd.net	Provides overall contract and client management, resource assignments, and technical and project management.
Craig Christian*	Task Manager/ Field Coordinator	Environment International *Phone*: 206.525.3362 *Email*: Craig.Christian@eiltd.net	Day-to-day technical lead in charge of field work. Coordinates and conducts data collection. Participates in data interpretation and preparation of deliverables. Communicates and coordinates with subcontractors.
Suzanne Dolberg	QA Officer	Environment International *Phone*: 206.525.3362 *Email*: Suzanne.Dolberg@eiltd.net	Provides project quality assurance oversight.
Field Staff	Scientists/ Engineers	Environment International *Phone*: 206.525.3362	Conduct field activities with oversight from Project Manager/Task Manager. Oversee subcontractor field activities. Communicate and coordinate with the Project Manager.
Subcontracted Services	Laboratory Services	Analytical Laboratory TBD	Analyzes samples for chemical constituents.
		University of Washington Isotope Geochemistry Lab	Analyzes samples for stable lead isotopes.

3. SCOPE OF WORK

This section introduces the project (Section 3.1) and describes the purpose and objectives of conducting a porewater assessment in the Upper Columbia River (Section 3.2). A brief description of the project tasks required for accomplishing the project objectives is provided (Section 3.3) as is a proposed schedule for completing the tasks (Section 3.4).

3.1 Introduction

The purpose of the porewater sampling assessment effort described herein is to characterize porewater quality and to measure lead isotope ratios, as feasible, in porewater in areas with sediment containing slag along the upper reach of the Upper Columbia River (UCR) above United States Geological Survey (USGS) river mile (RM) 730.

EI has developed this Sampling and Quality Assurance Plan (SQAP) as part of the comprehensive Field Task Work Plan (FTWP) required prior to conducting field work. The comprehensive FTWP will consist of this document and a site-specific Health and Safety Plan (HSP). The SQAP was prepared in accordance with US Environmental Protection Agency (EPA) guidance. EI also utilized information from a previous Ecology study to inform appropriate sample collection methods and analyses. This includes Ecology's 2009 Study, *High-resolution Porewater Sampling near the Groundwater/Surface Water Interface* (Publication No. 09-03-017).

3.2 Study Objectives and SQAP Purpose

The objective of the UCR In-Situ Porewater Assessment (Study) is not to characterize the extent of porewater contamination in the UCR, but to characterize contaminant concentrations and lead isotopic ratios within porewater. To this end, the goals of this study are to:

1. Obtain information on the concentration of dissolved and total metals in porewater in areas of slag contamination beneath the groundwater/surface water interface;
2. Obtain information on the general chemistry of porewater in areas of slag contamination; and
3. Assess the practicability of obtaining lead isotope ratios from porewater samples.

The purpose of the SQAP is to describe the field sampling and data gathering methods to be used during the UCR In-Situ Porewater Assessment. This document also includes information regarding the study objectives, background information and site conditions, sampling objectives, sampling locations and frequency, sampling procedures and equipment, task management responsibilities, and a proposed schedule for completion of field investigations and reporting activities. Specifically, the SQAP describes detailed sampling and analytical standard operating procedures (SOPs); quality assurance/quality control (QA/QC) methods to ensure that the results of the work performed satisfy the data quality objectives (DQOs) dictated by the intended use of the data; project instructions; laboratory method detection limits; reporting limits; data assessment criteria; and data evaluation procedures.

3.3 Project Tasks

The tasks associated with this project are as follows:

Task 1 – Porewater Assessment. Task 1 involves SQAP development and project management activities as well as collecting porewater samples from pre-selected locations along the UCR north of USGS RM 730. The subtasks associated with this task are described in detail in Section 5 of this document.

Task 2 – Data Analysis and Validation. Task 2 includes submitting the samples collected during Task 1 to analytical laboratories and reviewing the data to determine if they meet the DQOs established for this study. Data will be evaluated to assess porewater quality in subsurface sediments consisting primarily of slag.

Task 3 – Reporting. A final project report will be completed after the analytical results have been received and validated. The final project report will include the following:

- Description of the porewater assessment activities;
- Tabulated analytical results of samples collected during the assessment;
- Deviations from the approved SQAP;
- Discussion and analysis of how the study met project objectives; and
- Recommendations for additional work, if any, and justifications based upon DQOs.

3.4 Project Schedule

Table 3-1 presents the proposed schedule for completing the tasks involved with the UCR In-Situ Porewater Assessment. Field work is anticipated to occur in June 2010.

Table 3-1
Proposed Columbia River Porewater Assessment Schedule

Task	Proposed Start Date	Proposed Completion Date
Task 1 – UCR In-Situ Porewater Assessment		
Develop Draft SQAP	May 17, 2010	June 2, 2010
Review and Approval of SQAP	June 2, 2010	June 11, 2010
Finalize SQAP	June 28, 2010	July 16, 2010
Procure Subcontractors and Equipment	July 16, 2010	July 30, 2010
Mobilize to Site	August 2, 2010	August 2, 2010
All Field Work and Sampling	August 3, 2010	August 10, 2010
Task 2 – Data Analysis and Validation[1]		
Submit All Samples to Laboratory	August 4, 2010	August 11, 2010
Laboratory Analysis and Reporting	August 5, 2010	August 16, 2010
Data Validation	August 17, 2010	August 20, 2010
Data Analysis	August 20, 2010	September 13, 2010

Table 3-1 Notes:

1. Assumes a 14-day turnaround time for most analyses. Other analyses may require longer turnaround times.

4. SITE CONDITIONS

This section establishes general site conditions affecting the types and locations of samples expected to be collected as part of this study. Section 4.1 describes the Upper Columbia River in the study area, site boundaries, and significant features within those boundaries. Site history is discussed in Section 4.2. Section 4.3 describes previous investigations that have been conducted on and near the areas of interest for this study.

4.1 Site Description

The UCR Site is located in north central Washington and extends along the Columbia River from the border between the United States and Canada downstream to the Grand Coulee Dam. Immediately upstream of the Grand Coulee Dam, the impounded Columbia River forms the Lake Roosevelt reservoir.

The Columbia River was free-flowing until 1933 when Rock Island Dam was constructed at USGS RM 483, followed by Bonneville Dam in 1937 at USGS RM 146, and then Grand Coulee Dam between USGS River Mile (RM) 596 and 597 in 1941. The main structure of the Grand Coulee dam was completed by December 31, 1941; it took less than a year for the reservoir to reach full pool elevation.

Lake Roosevelt's surface elevation, inflow, and outflow are systematically controlled by the U.S. Bureau of Reclamation in order to achieve flood control, irrigation, recreation, fisheries, navigation, flow regulation, and power generation objectives. Grand Coulee Dam has historically been operated to maximize the storage capability of the reservoir for retention of flood waters during the spring runoff, to meet irrigation demand and downstream flow targets during the dry summer months, and to maintain the highest pool levels possible for maximum power generation at all other times of the year. Although reservoir elevations are systematically managed, the extent of the elevation fluctuations can be somewhat unpredictable due to varying annual runoff flows. The wide variation in runoff strongly influences the extent of reservoir elevation change, resulting in a range of pool elevations.

The full pool elevation maintained in Lake Roosevelt is 1,290 feet above mean sea level. During the annual operating cycle, water levels in the reservoir are typically drawn down between January and April to accommodate increased spring flows. At full pool, Lake Roosevelt extends at least 133 miles upriver from the dam to USGS RM 730, which is within 15 miles of the Canadian border, and is bordered by over 600 miles of publicly available shoreline. At the northern end of the UCR Site, the free-flowing reach of the UCR is generally undeveloped, bordered by the Colville National Forest to the west and Highway 25 to the east (EPA 2008a).

The scope of this study is limited to the river corridor extending from USGS RM 730 just south of Northport, Washington, to USGS RM 745 at the US-Canadian border. This reach of river begins at the US-Canadian border. The first three miles of river in this reach are relatively shallow and narrow, retaining much of the river's historical hydraulic characteristics, and are expected to run free much of the time. Water depth at the Canadian border was reported to be approximately 14 feet and is consistent with soundings from the 1947–1949 surveys conducted by the U.S. Coast and Geodetic Survey. (EPA 2008a)

The next 12 miles of this reach – extending from USGS RM 742 to USGS RM 730 – are just upstream of the Lake Roosevelt reservoir and are influenced by the lake's pool level. As flow in the UCR varies and pool elevations change in response to dam operations, this section of the river transitions from a free-running riverine reach to the lacustrine (lake-like) reach, downstream. Reported water depths at the downstream end of this reach are 50 feet or more in the main channel. Several notable geomorphic features exist in this stretch of river. There is a large gravel bar at USGS RM 738 on the northern bank, across from Deadman's Eddy. Aerial photographs suggest that some minor depositional features exist at the downstream point of the bar. There are also well-defined erosional terraces marking various reservoir pool levels. This suggests that the gravel bar may be a relict feature pre-dating upstream flood-control operations and potentially pre-dating the construction of Grand Coulee Dam as well. At USGS RM 737, the channel thalweg makes several sharp turns between two islands: Steamboat Rock and Sand Point. Two minor tributaries enter the UCR at this point, Big Sheep Creek on the northern bank and Deep Creek on the southern bank. Although these tributaries are small, aerial photographs suggest that both tributaries exhibit deltaic features at their confluence with the UCR, suggesting that these creeks may be an important source of native watershed sediments to the UCR downstream of the U.S.-Canadian border. The mouths of both tributaries are well-protected by backwaters, and the mouth of Big Sheep Creek is protected further by the two islands. (EPA 2008a)

Detailed characterizations of the riverbed between USGS RM 745 and USGS RM 730 are not available, although the information that does exist indicates that the bed consists of large (non-cohesive) particle types—gravel, cobbles, and boulders (EPA 2008a).

4.2 Previous Investigations

4.2.1 Ecology Sediment Sampling Events

Between May 2007 and May 2008, Ecology collected sediment samples from locations along the UCR. The May 2007 study was a one-day site reconnaissance that involved identifying depositional areas along the UCR and collecting ten sediment samples from near-shore, side-bank locations for chemical characterization. In February 2008, Ecology collected two sediment samples from the southeastern bank of the beach at River Mile 743, referred to as Black Sand Beach, for the purpose of determining the chemical characteristics of the material there and to assess if follow-on toxicity testing would be necessary. Ecology then sampled Lake Roosevelt sediments in May 2008 for the purpose of assessing the toxicity of sediments to benthic invertebrates. This study also involved screening the sediments for total metal content with an x-ray fluorescence analyzer.

Details on how each sample was collected and the analytical results of those samples are in the following reports authored by Ecology:

- *Field Reconnaissance and Sediment Sampling Report, Upper Columbia River Site, Washington*. Dated August 2007, authored by Brendan Dowling. (Dowling 2007)
- *Upper Columbia River – Black Sand Beach Proposal to Conduct Static Acute Fish Toxicity Tests*. Dated March 6, 2008. (Ecology 2008b)

- *Summary of Sediment Sampling Activities to Support Preliminary Benthic Invertebrate Colonization Studies of Lake Roosevelt Sediments*. Technical Memorandum dated June 2008. (Ecology 2008a)

5. SAMPLING & ANALYSIS PLAN

The UCR In-Situ Porewater Assessment is primarily focused on documenting porewater quality conditions in slag-bearing sediments. This study also will obtain data with the intent of evaluating stable isotope ratio detections to investigate the source of lead present in slag-impacted porewater. This section describes the sampling and analysis activities that will be conducted during this assessment, including the types of samples, rationale for sample locations, sample collection methods, and the proposed chemical analyses. This section also describes the tasks associated with the porewater assessment and the work that will be performed to complete the tasks.

The types and locations of samples to be collected as part of this survey are presented in **Table 5-1**. Standard operating procedures (SOPs) that will inform this project are listed in **Table 5-2**; all SOPs are provided in **Appendix A**. **Table 5-3** presents a summary of the samples to be collected by EI as part of this investigation, including media to be sampled and the analyses to be performed on the samples. Field quality control samples that will be collected as part of this project as well as the sample analysis requirements, including analyses to be performed, required sample volumes, containers, preservation methods, and maximum holding times also are presented in Table 5-3. **Table 5-4** describes analytical sensitivity requirements for project samples.

5.1 Mobilization/Demobilization

The field investigation will begin with mobilization activities. Mobilization of staff and equipment will be required to prepare for the field effort and will continue throughout its duration to support the various subcontractor services and field tasks. Mobilization activities may include:

- Procuring subcontractors;
- Orienting field personnel on proposed activities and health and safety protocols;
- Leasing and purchasing expendable and non-expendable items;
- Communicating and coordinating with site owners and/or the CCT for site access and cultural resource oversight;
- If necessary, obtaining tribal permits to conduct sampling at sites within the Columbia River.
- If necessary, obtaining state permits to install temporary in-water wells.
- Establishing a temporary field office or work area;
- Assembling and transporting field equipment to and from the Site(s);
- Coordinating and scheduling subcontractors; and
- Establish boat-based operations.

Subcontractor procurement will include final evaluation and selection of subcontractors for off-site analytical laboratory services. Investigation-derived waste (IDW) management services shall be performed by EI, which is discussed further in Section 5.8. All subcontractors will be required to adhere to the procedures presented in this SQAP. Subcontractors will also be required to comply with all state and local certification requirements. All employees and subcontractors[1] of EI who will participate in

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[1] Subcontractors or other non-EI field work participants that participate in field activities will be required to have their own health and safety plan and will be responsible for monitoring their own safety. However, if any of their activities conflict with EI's HSP, then the activities will need to be re-evaluated.

field activities at the Site are required to read the EI's *Site-Specific Health and Safety Plan* and sign that they understand and will abide by its requirements. Field sampling will only be conducted by EI employees. A state of Washington registered engineer with resource protection well construction expertise will be on site at all times. No subcontractors are anticipated to be involved with the field work portion of this project.

The back of a work truck/van will serve as a temporary, near-by field office for each field station. The mobile field station will include a work table to process the samples. A motor boat will be utilized for transportation, as well. The equipment and disposable items necessary to perform the various field activities will be ordered and stocked at EI's offices until the time they are needed in the field. Demobilization activities will coincide with the completion of the field effort and will consist of conducting a final inspection of each work site to ensure no sampling equipment or trash is left behind and assembling and transporting field equipment back to EI's offices.

5.2 Utility Clearance

Utility clearance is not necessary for this field event as sampling will be occurring in areas where utilities are not likely to be present.

5.3 Sampling Activities

This study is aimed at evaluating the quality and general chemistry of porewater in slag-bearing sediments at the request of the attorneys representing the CCT and the State of Washington. The study will also evaluate the feasibility of measuring stable lead isotope ratios in the porewater of slag-bearing sediment. Secondary study objectives include evaluating, as feasible, the impacts of diurnal flows on porewater quality and evaluating changes in porewater chemistry along the study reach.

In order to obtain porewater samples representative of long-term water quality conditions, it is important to collect porewater from a regime of suitable hydraulic conditions. As the hyporheic zone is constantly in flux, steps will be taken to minimize dilution of porewater samples by entrainment of surface water. Therefore, porewater samples will be collected from depths below the groundwater interface to minimize entrainment of surface water. To the extent possible, samples will be collected preferentially from depth horizons characterized by anaerobic porewater conditions within the slag-bearing sediments. Water will be withdrawn at slow, controlled rates to avoid any potential surface water breakthrough.

Four sampling sites along the UCR between Northport, Washington, and the U.S.-Canadian border have been selected for this study. Two of the four sampling locations were selected because sediment quality and slag composition in these areas has previously been assessed. Because the study seeks to examine in-situ porewater quality in slag-bearing sediments, sampling near previously sampled locations increases the likelihood of obtaining porewater from slag-bearing subsurface sediments. Secondly, because samples will be collected in close proximity to previously collected sediment samples, it will be possible to directly evaluate relationships between sediment and porewater at each location, without additional sediment analysis. The previously sampled locations proposed for the UCR In-Situ Porewater Assessment include Black Sand Beach (RM 743) and Deadman's Eddy (RM 737.5).

Two additional sites are proposed for porewater sampling where the slag composition and sediment quality is not fully defined. These locations include the midstream bar near the U.S.-Canadian border (RM 745) and a yet-to-be-determined location that will be selected in the field based on accessibility and a high potential for the presence of slag. Prior to beginning field work, EI will consult available data from previous investigations to identify a number of locations that may be suitable for sampling. If sediment quality information is not available for the specific locations selected in the field, it will be necessary to collect sediment samples from the locations in question. Sediment sample collection is discussed in Section 5.3.3.

Table 5-1 describes each sample site proposed for the UCR In-Situ Porewater Assessment and the associated sampling and analyses proposed for these sites.

Because there is interest in evaluating variability in slag-associated porewater chemistry at various locations along the study area downstream from the U.S.-Canadian border, two locations will be sampled at each sample site. This will include locations, to the extent practicable, on the upstream and downstream sides of the sediment features to be sampled as part of this study.

Porewater samples will be collected from sandbars or locations close to the river bank that may, at times, be submerged but are accessible during the sampling event. It is important to obtain samples that closely represent the actual porewater conditions by minimizing the potential introduction of surface water. In-water locations will be avoided to minimize the possibility that surface water may enter the porewater sampling apparatus during sample collection and to ensure safety of sampling personnel. Sampling locations should be positioned close to the shoreline (i.e. within a few meters), and samples should be collected from the maximum depth achievable with the sampling equipment. Flow rates during sampling should generally be less than 50 mL per minute (mL/min).

To confirm the suitability of selected locations for porewater sampling, field screening will be conducted for the presence of slag and field parameter measured conditions including dissolved oxygen.

In order to determine if slag is present at the targeted porewater sampling location and depth, sediment core samples will be collected using either a hand auger or a shovel at a location in the vicinity but downgradient of the porewater sampling location. Subsurface sediment samples will ideally be collected to the maximum depth to which the porewater sampling device can be advanced, up to a total depth of six ft bgs, and visually evaluated for the presence of slag. Slag is visually distinctive, consisting primarily of black, fine-grained sand-size particles. If the presence of slag cannot be confirmed visually within the depth interval accessible to the sampling equipment, a new sampling location will be targeted upstream from the original location and the screening process repeated. If subsurface sediment samples cannot be collected due to field conditions, other lines of evidence may be cited by the field sampling team as evidence for slag presence. This may include hydrology and geology of the area, historic observations, and visual observations made on any material extracted with the hand-operated sediment coring device or shovel.

Once a suitable location with slag-bearing sediment has been confirmed, porewater redox conditions will then be assessed. After installing the porewater sampling device to the maximum depth it can be advanced [up to 6 feet (ft) below ground surface (bgs) for a pushpoint sampler], the temporary well point will be purged and the effluent stream monitored periodically for water quality parameters including temperature, pH, specific conductance, dissolved oxygen and oxidation-reduction potential (ORP) using a multi-parameter meter fitted with a small-volume flow-through cell , as described in Section 5.3.3.2 below. Once parameter readings have stabilized, they will be compared to a similar set of readings previously taken from the river water in the immediate vicinity of the porewater sampling location. If dissolved oxygen and/or ORP readings of porewater are significantly lower than river water, this is indicative that anaerobic porewater is being sampled. Specific conductance, temperature, and pH may also differ from the values measured in the surface water sample. Field testing of porewater for ferrous iron using a portable colorimeter will also be performed to evaluate the existence of reduced oxygen porewater conditions. If water quality meter readings for porewater are similar to those of surface water, this is indicative of the presence of surface water and a new sample location at the sample site may need to be identified. To the extent practical, the new porewater sampling location should be relocated upgradient of the original sampling location.

Because river water levels fluctuate daily in response to dam operations on the Columbia River, it is of interest to assess potential variability in porewater conditions due to groundwater-surface water interactions over the diurnal cycle. During the study, to the extent feasible, attempts will be made to collect samples during high flow rate periods and low flow rate periods to assess potential diurnal effects of dam operations on porewater quality. Sampling will be attempted at each sample site at two consistent times, targeting anticipated high end and the low end of diurnal flow. The real-time river flow will be recorded from the U.S. Bureau of Reclamation website,[2] or if that is not possible, the sample time will be recorded and post-correlated with the flow in the river at the time samples are collected.

Table 5-1
Proposed Sample Sites for the UCR In-Situ Porewater Assessment

Site	Primary Purpose	Type of Sample	Analysis	Maximum Number of Field Samples
Midstream Bar @ RM 745	Characterize physical and chemical characteristics of porewater & sediment at sediment feature near the U.S.-Canadian Border	Subsurface Sediment Probe	Visual Observation	2 samples
		Bulk Sediment Sample	Target Analyte List Metals (TAL) analysis	2 samples for each analysis
			Stable lead isotope analysis	
		Porewater	Water Quality Parameters	2 samples at both sample locations for each analysis
			Ferrous Iron	
			TAL Metals analysis	
			Stable lead isotope analysis	
Black Sand Beach @ RM 743	Characterize physical and chemical characteristics of porewater at a location of known	Subsurface Sediment Probe	Visual Observation	2 samples
		Porewater	Water Quality Parameters	2 samples at both sample locations for each analysis
			Ferrous Iron	
			TAL Metals analysis	
			Stable lead isotope analysis	

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[2] http://www.usbr.gov/pn-bin/graphrt.pl?cibw_yr

Table 5-1
Proposed Sample Sites for the UCR In-Situ Porewater Assessment

Site	Primary Purpose	Type of Sample	Analysis	Maximum Number of Field Samples
	sediment quality.			
Deadman's Eddy @ RM 737.5	Characterize physical and chemical characteristics of porewater at a location of known sediment quality.	Subsurface Sediment Probe	Visual Observation	2 samples
		Porewater	Water Quality Parameters	2 samples at both sample locations for each analysis
			Ferrous Iron	
			TAL Metals analysis	
			Stable lead isotope analysis	
To be Determined (TBD)	Characterize physical and chemical characteristics of porewater & sediment at slag-bearing sediment feature	Subsurface Sediment Probe	Visual Observation	2 samples
		Bulk Sediment Sample	TAL Metals analysis	2 samples for each analysis
			Stable lead isotope analysis	
		Porewater	Water Quality Parameters	2 samples at both sample locations for each analysis
			Ferrous Iron	
			TAL Metals analysis	
			Stable lead isotope analysis	

At each sampling site, EI will be collecting a number of samples and measurements as described in Table 5-1. Each of the sample and measurement types to be performed at the various study locations are described in the following sections.

5.3.1 Subsurface Sediment Probe

In order to confirm that porewater samples are collected from a slag-bearing horizon, it is useful to verify that the horizon being sampled contains slag. Hence, at each river bar visited, hand-auguring or shoveling may be needed to confirm that the bar feature has appropriate locations for sampling. The field crew will conduct a subsurface sediment probe to visually assess whether or not slag is present at the depth the porewater sampling device will be installed. The subsurface sediment probe will be installed approximately 10 feet downgradient (downstream) of the targeted porewater sampling location. The subsurface sediment probe will be installed after a porewater sampling location has been selected but prior to installing the porewater sampling device. Porewater sampling methods are discussed in Section 5.3.3.

The subsurface sediment probe may be installed either by using a hand-operated sediment coring device, similar to the device shown in Section 8.2 of ***EI SOP No. 1003 – Sediment Collection & Sampling*** (Appendix A), using a shovel, or a combination of both. If a hand-operated sediment coring device is used, the procedure for using this equipment outlined in Section 8.2 of EI SOP No. 1003 shall be followed. If the hand-operated sediment coring device is unsuccessful at reaching the depth at which the porewater sample was collected, the EI field crew will utilize a clean shovel to excavate sediment/soil to the porewater sample depth or to a depth considered sufficient to make a determination regarding the visual presence of slag. If a sediment sample cannot be collected from the target depth of the porewater sample, other lines of evidence from the area will be taken into account and a field decision reached as to whether the sample has been taken from a horizon at which slag is present. Other lines of evidence may include hydrology and geology of the area, historic observations, and visual observations made on any material extracted with the hand-operated sediment coring device or shovel.

Upon extraction of the subsurface sediment core, a photograph of the sample material will be taken and visual observations will be noted in the project logbook. If, based on visual observation and professional judgment, a significant fraction of the subsurface sediment sample appears to consist of slag, porewater samples collected from this location will likely provide data in support of the project objectives. Otherwise, a new location will need to be selected upgradient of the original location and the screening process repeated until a suitable location for porewater sample collection is identified.

Subsurface sediment probes will be installed, generally and as feasible, at upstream and downstream sample locations at each sample site.

Sediment material potentially extracted from the sample location during the process of installing the subsurface sediment probe will be returned to the borehole if natural collapse has not occurred. Sediment sampling equipment shall be decontaminated in between sample locations in accordance with ***EI SOP No. 1008 – Field Equipment Decontamination***.

5.3.2 Subsurface Sediment Samples

At sample sites where the metals content of the subsurface sediments is unknown or cannot be inferred from previous information, sediment samples will be collected during the subsurface sediment probe to be submitted for laboratory analysis. There are at least two sample sites where subsurface sediment samples will be collected. Additional sites will be sampled if suitable conditions in slag-bearing sediments are not identified at Black Sand Beach or Dead Man's Eddy. One of these two sample sites is located at RM 745 and referred to as Midstream Bar. A second sample site will be selected, likely downgradient of Dead Man's Eddy, based on ease of access, presence of a sand bar or similar sediment feature that is typically underwater but accessible during fieldwork. The potential for slag-bearing sediments should also be high at the selected location. Prior to beginning field work, EI will consult available data from previous investigations and confer with Washington State Department of Ecology experts to identify a number of locations that may be suitable for sampling.

Subsurface sediment samples will be collected consistent with Section 5.3.1, however, instead of returning the sediment to the borehole after visually assessing the sample, the sediment will be placed in the appropriate sample jars for the anticipated analyses.

The sediment samples collected during this study will be subjected to the following analyses:

- Target Analyte List (TAL) metals,
- Total Organic Carbon (TOC), and
- Stable Lead isotopes [Lead (Pb)-204, Pb-206, Pb-207, Pb-208].

Sediment samples submitted for TAL metals analysis will be digested using the digestion method outlined in EPA SW-846 Method 3050B. Trace element concentrations will be determined using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) by EPA SW-846 Method 6020A or Inductively Coupled Plasma-Atomic Emission Spectrum (ICP-AES) by EPA SW-846 Method 6010 depending on expected concentrations. All of the sediment samples to be analyzed for TAL metals collected during this study will be submitted to an EPA-certified laboratory.

In order to obtain supplemental data on stable lead isotope ratios in sediment from different locations along the Upper Columbia River, EI will collect a sample consisting primarily of sandy/slag material for stable lead isotope analysis. EI will place the sediment in a 4-ounce, clear glass jar which will then be placed in a re-sealable plastic bag. The sample bag will be placed in a cooler with ice then shipped to EI's office in Seattle, Washington. The samples will be transferred by EI personnel to a subcontracted laboratory for stable lead isotope analysis using the method outlined in Harkins et al (2008).

The proposed chemical analyses to be performed on the sediment samples, preservation methods, holding times, and sample volumes are presented in **Table 5-3a**. Analytical sensitivity and project criteria are provided in **Table 5-4**. Method reporting limits are specified in **Table 5-5**.

Following sample collection, the sampling device will be pulled and the boreholes allowed to collapse on themselves.

5.3.3 Porewater Samples

The ultimate objective of this study is to obtain data on porewater conditions in slag-bearing sediments within the Upper Columbia River. In order to obtain a representative picture of porewater conditions in these sediments, porewater samples will be need to be collected in a manner that minimizes the potential for incorporating surface water.

5.3.3.1 Assessment of Porewater Redox Conditions

To assist in assessing if porewater samples collected are representative of conditions within slag-bearing deposits with minimal influence from surface water exchange, porewater redox conditions will be screened prior to sample collection.

To assess porewater field chemistry conditions, the EI field crew will install a porewater sampling device to the maximum depth it can be advanced, up to 6 ft bgs. The temporary well point will be purged and the effluent stream monitored periodically for water quality parameters including temperature, pH, specific conductance, dissolved oxygen and oxidation-reduction potential (ORP) using a multi-parameter meter fitted with a small-volume flow-through cell , as described in section 5.3.3.2 below. Once parameter readings have stabilized, they will be compared to a similar set of readings previously taken from the river water in the immediate vicinity of the porewater sampling location. If dissolved oxygen and/or ORP readings of porewater are significantly lower than river water, this is indicative that reduced oxygen porewater is being sampled. Specific conductance and pH may also differ from the values measured in the surface water sample. Field testing of porewater for ferrous iron using a portable colorimeter will also be performed to evaluate porewater conditions. If monitored water quality parameter readings for porewater are similar to those of surface water (typically within ±10 % for specific conductance and dissolved oxygen, ±50 mV for ORP, or ±0.1 for pH) this can be taken as an indication that porewater conditions at the sample location are dominated by surface water exchange. A new sample location at the sample site will then be identified, and the screening repeated. To the extent practical, the new porewater sampling location should be relocated upgradient of the original sampling location.

As a guide, a maximum of six sample locations[3] will be tested at each sample site before abandoning the sampling effort at that site. If porewater from the all sample locations are determined to be dominated by surface water based on water quality parameters, then a field decision will be made whether or not to collect porewater samples from the sample site.

At each sample site, an upstream and downstream porewater sample will be collected. The proposed downstream sample location will be evaluated first and subsequent locations will move upstream until the suitable upstream sample location is identified.

Shortly after installing the porewater sampling device (discussed in Section 5.3.3.2), the temporary well-point will be purged. Porewater from the well-point will be collected and screened for the presence of dissolved oxygen using a handheld water quality meter with the capacity to measure dissolved oxygen, pH, ORP, turbidity, temperature, and conductivity. The existence of anaerobic conditions will also be assessed by screening the water sample for the presence of ferrous iron.

Selection of the multi-parameter water quality meter used as part of this study will be left to the discretion of the field team leader but should have the following characteristics:

- Requires a minimal volume of water to obtain accurate readings in order to increase efficiency and minimize disturbance of the well prior to sampling, and fitted with a small volume flow-through cell.
- Provides real-time, accurate information on dissolved oxygen, pH, ORP, turbidity, temperature, and conductivity.
- Has a luminescent dissolved oxygen probe.

The multi-parameter water quality meter will be calibrated on a daily basis prior to use in accordance with ***EI SOP No. 5204 – Field Screening Equipment Calibration*** and with the manufacturer's instructions.

Field screening for ferrous iron will be accomplished using a portable colorimeter or similar instrument with a flow cell. Detectable concentrations of ferrous Fe^{2+} (above 0.01 mg/L) will assist in confirming the existence of "anaerobic" conditions.

Water purged from the porewater sampling device will be discharged directly to the ground surface after field screening measurements have been collected. Once a suitable porewater sampling location has been identified and water quality parameters have stabilized to the satisfaction of the field team,

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[3] Three sample locations at the upgradient location and three sample locations at the downgradient location.

sample collection may proceed. Stability criteria are generally guided by the maximum difference between three successive readings, as follows:

Measurement	**Maximum Difference**
pH	<0.1 units
ORP	<50 mV
Specific conductance	<10%
Temperature	<0.1 °C
Dissolved oxygen	<10%
Turbidity	<10%

5.3.3.2 Porewater Sample Collection

The type of samplers available to collect the porewater samples will be push-probe type sampler devices. An advantage of the push-probe sampler is ease of use and synoptic data acquisition. It does not require equilibration and generates minimal disturbance to the surrounding sediment. Direct sampling of porewater should provide a good representation of metals concentrations and lead isotope ratios in the porewater proximal to the sample point.

The push-point samplers have a long barrel that can be pushed directly into the sediment. A rod may fill the inner sampling chamber until the sampler is pushed to the sampling depth, at which time the rod is removed and the chamber allowed to fill with water. Other devices utilize disposable points. The water is then sampled immediately using a syringe or peristaltic pump (no equilibration time is required). Water samples can be field measured and/or filtered using inline devices.

There are a number of push-point samplers available to use that will provide porewater samples of sufficient quality to support this study. However, the porewater sampling equipment utilized as part of this study should be sturdy enough to withstand forces required to install them to depths up to 6 ft bgs while also maintaining the ability to obtain a valid porewater sample. It is also important to collect samples using equipment that will not introduce additional metals contamination. Equipment constructed of polyethylene or some other plastic material will be given preference over equipment constructed of steel. If a stainless steel sampler is used in conjunction with a steel riser pipe, any riser pipe used will be installed with polyethylene tubing to minimize contact of porewater with the metal surface during sample collection. If for any reason a stainless steel sampler must be used without inner tubing, rinsate blanks will also be collected and tested to evaluate the potential level of metals contribution from the sampling device.

Initially, the field crew will attempt to use a push-point sampler constructed of ¼-inch polyethylene tubing fitted with a polypropylene screen and installed using a stainless steel rod that pushes the tubing into the sediment, straightening out the tubing creating a temporary well. An example of this type of push-point sampler is made by MHE Products and called the SedPoint sampler. If this equipment is unsuccessful at obtaining porewater samples, a stainless steel push-point sampler fitted with a polyethylene tube liner will be employed. A Solinst stainless steel drive-point piezometer may be utilized as a backup sampling system. Information on the types of samplers that would be acceptable for use on this project is provided in **Appendix B**.

Prior to sampling, the sampling location will be marked and recorded using Global Positioning System (GPS) equipment. At each of the actual sampling locations a pre-cleaned push-point sampler will be installed in general accordance with relevant procedures provided in **Ecology's Environmental Assessment Program SOP No. 061 – SOP for Installing, Measuring, and Decommissioning Hand-Driven In-Water Piezometers** (Appendix A) and/or via the manufacturer's instructions. This typically involves forcing the device with a tapping or twisting motion into the slag/sediment at the on-shore or near-shoreline sediment feature into the underlying shallow river-saturated sediment to a depth up to 6 ft bgs or until refusal is met and its guard-rod removed. A measuring tape will be used document depth measurement.

An appropriately sized piece of Tygon tubing will be attached to a low-flow rate peristaltic pump, connected at one end to the sampler and placed at the other end into a disposable sample cup. The peristaltic pump will be activated at the lowest feasible flow rate setting for pulling sample porewater from the depth that the porewater sampling device is screened. Approximately 500 milliliters (mL) of water will be initially withdrawn for conditioning the tubing and reducing turbidity, as determined by visual inspection, before collecting samples for water quality measurements and ferrous iron screening.

After the initial 500 mL has been withdrawn and turbidity has been reduced, water will be collected in the multi-parameter water quality meter's sample chamber. Conductivity and other field parameters will be measured per annular volume until generally stable readings are reached and it is determined that the porewater sampling device is drawing porewater from the targeted depth. The water quality probe flow cell will be purged for at least four cell volumes, and until stability criteria described earlier are met before sampling.

Porewater samples will be collected by directing the flow into the appropriate sample bottles, taking care not to touch the outside of the tubing to the bottle opening. Between filling sample bottles, the end of the sample tubing will be covered with a clean plastic bag. After each sample bottle has been filled, the cap will be placed on the bottle and the tubing end returned to the sample cup. Each sample bottle will be labeled with the site location, sample name, sample date, sample time, and other pertinent information as described in ***EI SOP No. 1004 – Chain-of-Custody & Sample Labeling***. The sample bottles will be placed into a cooler on ice for storage until the samples can be transferred to a laboratory for analysis.

In order to assess the impacts of diurnal changes in river flow rates on porewater quality, the EI field crew will pursue the goal of timing a sampling event at each sample site to correspond with an anticipated lower flow period of the river's flow cycle. If feasible, at each station the installed porewater sampling device will be left in place so that a second porewater sample can be collected during a different flow period of the river's expected daily flow cycle. In order to correlate the river flow rate to each porewater sample, it will be important to document the exact time each sample was collected in the project log book. In addition to collecting porewater samples during the high-flow period, water quality parameters and ferrous iron concentrations will also be measured and recorded.

5.3.3.3 Sample Analyses

The porewater samples collected during this study will be subjected to the following analyses and tests:

- Water quality parameter testing: dissolved oxygen, pH, temperature, ORP, turbidity, and conductivity;
- Ferrous iron testing;
- TAL metals – total and dissolved;
- Alkalinity
- Anions (sulfate, nitrate, chloride, fluoride)
- Mercury;
- Total organic carbon; and
- Stable lead isotopes (Pb-204, Pb-206, Pb-207, Pb-208).

Water quality parameter testing and ferrous iron screening were discussed in Section 5.3.3.1.

Porewater samples submitted for TAL metals analysis will be analyzed for total metals and for dissolved metals using ICP-MS by EPA SW-846 Method 6020A, except in cases where there is a large amount of the trace element present in the sample. In these cases ICP-AES by EPA SW-846 Method 6010 will be used. The proposed analyses will be completed by an EPA-certified laboratory. A total of 2 liters of porewater are necessary for running these two analyses. The first sample will not be filtered, while the second sample will be filtered in the field using a clean, 0.45-micron filter. Porewater samples will be filtered using an in-line filter following the manufacturer's instructions. Samples will be collected in certified pre-cleaned, 1-Liter (L), high-density polyethylene (HDPE) bottles preserved with nitric acid to a pH of 2.

Alkalinity will be measured by EPA 310.1 or equivalent, and anions will be measured by EPA Method 300.1 or equivalent.

One porewater sample from each sampling site will be analyzed for total and dissolved mercury using EPA SW-846 Method 7471A. No extra sample volume will be required to analyze this sample. Total organic carbon in the porewater sample will be measured to provide information on metals cycling within porewater.

Porewater samples for stable lead isotope analysis will be collected in a 1-L, HDPE bottle which will then be placed in a cooler with ice then shipped to EI's office in Seattle, Washington. The samples will be transferred by EI personnel to a subcontracted laboratory for stable lead isotope analysis using the method outlined in Harkins et al (2008).

The proposed chemical analyses to be performed on the porewater samples, preservation methods, holding times, and sample volumes are presented in **Table 5-3b**. Analytical sensitivity and project criteria are provided in **Table 5-4b**. Method reporting limits are specified in **Table 5-5**.

5.3.4 Quality Control Samples

To ensure data quality objectives are met, a number of quality control samples will need to be collected. The quality control samples will consist of Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples. MS/MSD samples are analyzed to determine if there is any interference with the sample matrix that may impact sample results. For inorganic analysis, there is no need to collect extra sample volume as the amount collected is sufficient to run the analysis on the field sample and to analyze the MS/MSD. EI will only need to designate one out of every 20 samples submitted for TAL metals analysis as an MS/MSD. This designation shall be written on the sample label and included as part of the sample name by adding “MS/MSD” to the end of the sample name.

5.3.5 Sample Naming

When logging and labeling porewater samples for analysis, samples shall be identified using the following notation:

Sample Site Code – Sample Media Code – Sample Number

Sample Site Codes are presented in the following table:

Sample Site	Sample Site Code
Midstream Bar	MSB
Dead Man’s Eddy	DE
Black Sand Beach	BSB
To-Be-Determined location	TBD

Sample Media Codes are as follows:

Sample Media	Sample Media Code
Porewater	PW
Sediment	SD
Quality Control	QC

For example, a porewater sample collected from the second sample site at Dead Man’s Eddy would have the following sample identification number: DME-PW-02

If a sample is considered a field duplicate (FD), the following naming schema applies:

Sample Site Code – Sample Media Code – Sample Number – FD

For example, the field duplicate of the third porewater sample collected from Black Sand Beach would have the following sample identification number: BSB-PW-03-FD.

5.3.6 Project Constraints

As with any project involving the collection of environmental samples, there are a number of constraints that may determine how this study is executed. The constraints can be both physical and temporal and are described in the next two sections.

5.3.6.1 Physical Constraints

Physical constraints on porewater sampling and data collection may include the following:

- High water levels in the river covering areas of interest and frequent river stage fluctuations.
- Sample locations that consist primarily of cobbles and other coarse materials making it difficult to install porewater sampling devices to depths representing desired conditions.
- Sample locations without slag deposits below the groundwater/surface water interface.
- Sample locations where the slag-bearing region is deeper than 6 ft bgs.

Alternate sample locations will be sampled if any of these physical constraints are encountered at a proposed sample site. The determination about whether to attempt an alternate sediment sample at an alternate location will be made in the field by the field team. Alternate field samples will likely be collected from the same sandbar as the original proposed location. These samples will be collected upstream of the original sample. If a suitable sample is unable to be collected at a particular sample site, the field team will identify a nearby location upstream or downstream that has similar physical characteristics to the original proposed location.

5.3.6.2 Temporal Constraints

During the annual operating cycle for the hydroelectric dams along the Columbia River, water levels in the Lake Roosevelt reservoir are typically drawn down between January and April to accommodate increased flows resulting from spring runoff, impacting flow conditions and river depths. Spring runoff also increases water levels and flow rates in the Upper Columbia River and may cover sandbars and river banks that are exposed during periods of low flow. In order to maximize the potential that areas of interest specified in this study are not underwater and easily accessible, field work should be completed before or following peak, seasonal river flows which make these areas inaccessible.

Table 5-2
Field Standard Operating Procedures

Project Sampling SOP	SOP Number	Revised Date
Sediment Sampling	EI-1003	Rev 1, 1/22/2009
Installing, Measuring, and Decommissioning Hand-Driven In-Water Piezometers	ECY-EAP-061	Rev 1, 9/1/2009
Chain-of-Custody and Sample Labeling	EI-1004	Rev 1, 1/12/2009
Quality Assurance/Quality Control Sample Collection	EI-1021	Rev 1, 1/22/2009
Field Equipment Decontamination	EI-1008	Rev 1, 1/12/2009
Environmental Sample Packaging and Shipping	EI-4034	Rev 0, 1/14/2009
Field Documentation and Forms	EI-4014	Rev 1, 1/12/2009
Investigation-Derived Waste Handling	EI-4033	Rev 0, 1/13/2009
Field Screening Equipment Calibration	EI-5204	Rev 0, 3/8/2010

TABLE 5-3a. Sediment Sampling and Analysis Methods Requirements Summary

Specific Analysis Requested				TAL metals	TOC	Stable Lead Isotopes
Analytical Method				EPA 6020A, 7471A (Hg)	Plumb (1981)[1]	Harkins et al (2008)[2]
Preservation Requirements				cool to 4 °C immediately after collection	cool to 4 °C immediately after collection	cool to 4 °C immediately after collection
Sample Holding Time				6 months; 28 days (Hg)	14 days	NA
				Container/ Sample Volume, Notes		
Sample ID	**Depth**	**Rationale**	**Field Analyses/ Observations**	1x 8-oz wide-mouth glass jar[3]	1x 4-oz wide-mouth glass jar	1x2-oz wide-mouth glass jar
Sample Site Code – Sample Media Code – Sample Number	0 to 6 ft bgs	Characterize physical and chemical characteristics of sediment.	Visual Characterization			
Field Sampling						
total field samples				8	8	8
total field duplicates				1	1	1
total field/rinsate blanks (1/day)				NA	NA	NA
total trip blanks (VOC only)				NA	NA	NA
total temperature blanks (not analysis-specific)				NA	NA	NA
total laboratory QC dup/MS/MSD[6]				1	NA	NA
Total Analyses				10	9	9

Table 5-3a Notes:

[1] Plumb, R. H. Jr., Procedures for Handling and Chemical Analysis of Sediment & Water Samples, May 1981, USACE Publication AD/A103788

[2] Harkins, S.A., Appold, M.S., Nelson, B.K., Brewer, A.M., and Groves, I.M., 2008, "Lead isotope constraints on the origin of non-sulfide zinc and sulfide zinc-lead deposits in the Flinders Ranges, South Australia": *Economic Geology*, v. 103, pp. 353-364.

[3] 8-oz short, wide mouth, straight-sided glass jar, 70-mm neck finish; closure: polypropylene or phenolic cap, 70-400 size, 0.015-in. PTFE liner

[4] The same 16-oz, wide-mouth, straight-sided glass jar submitted for Grain Size analysis can be submitted for the Bulk Density sample.

[5] Uses the same 4-oz jar submitted for TOC analysis.

[6] Samples for laboratory QC will be designated in the field, one dup/MS/MSD per 20 samples

Table 5-3a Key:

bgs	below ground surface	mm	Millimeter
°C	Degree Celsius	MS	Matrix Spike
EPA	Environmental Protection Agency	MSD	Matrix Spike Duplicate
ft	Feet	oz	Ounce
g	gram	PTFE	Polytetrafluoroethylene
Hg	Mercury	QC	Quality control sample
ID	Identification	TAL	Target Analyte List
in	inch	TOC	Total organic carbon
L	liter		

Table 5-4a. Analytical Sensitivity and Project Criteria

Parameter	Method	Reporting Limit (RL)	MS Recovery Limits (%)	MS/MSD or Laboratory Duplicate RPD Limits (%)	Field Duplicate RPD Limits (%)
TAL metals	EPA Method 6010, 7471A (Hg)	See Table 5-5	75-125	≤ 20	≤ 50
TOC	Plumb (1981)[1]	0.02%	75-125	≤ 20	30
Stable Lead Isotopes	Harkins et al (2008)[2]	NA	NA	NA	NA

Table 5-4a Notes:

[1] Plumb, R. H. Jr., Procedures for Handling and Chemical Analysis of Sediment & Water Samples, May 1981, USACE Publication AD/A103788

[2] Harkins, S.A., Appold, M.S., Nelson, B.K., Brewer, A.M., and Groves, I.M., 2008, "Lead isotope constraints on the origin of non-sulfide zinc and sulfide zinc-lead deposits in the Flinders Ranges, South Australia": *Economic Geology*, v. 103, pp. 353-364.

Table 5-4a Key:

ASTM	American Society for Testing & Materials	RL	Reporting Limit
EPA	Environmental Protection Agency	RPD	Relative Percent Difference
Hg	Mercury	TBD	To be determined by analytical laboratory
MS	Matrix Spike	USACE	US Army Corps of Engineers
MSD	Matrix Spike Duplicate		
NA	Not Applicable		

TABLE 5-3b. Porewater Sampling and Analysis Methods Requirements Summary

Specific Analysis Requested				TAL Metals (Total)	TAL Metals (Dissolved)	TOC	Stable Lead Isotopes	Alkalinity	Anions
Digestion Method				EPA 3050B	EPA 3050B	None	Harkins et al (2008)[5]	None	None
Analytical Method				EPA 6020 (ICP-MS), 7471A (Hg), EPA 6010 (ICP-AES)[1]	EPA 6020 (ICP-MS), 7471A (Hg), EPA 6010 (ICP-AES)[1]	EPA 415.1/9060A	Harkins et al (2008)[4]	EPA 310.1	EPA 300.1
Preservation Requirements				HNO_3 to pH < 2 and cool to 4 °C immediately after collection	HNO_3 to pH < 2 and cool to 4 °C immediately after collection	H_2SO_4 to pH < 2 and cool to 4 °C immediately after collection	Cool to 4 °C immediately after collection	Cool to 4 °C immediately after collection	Cool to 4 °C immediately after collection
Sample Holding Time				6 months; 28 days (Hg)	6 months; 28 days (Hg)	None	None	14 days	28 days
Sample ID	**Depth**	**Rationale**	**Field Analyses/ Observations**	1x 1-L HDPE Bottle[2]	1x 1-L HDPE Bottle[2]	1x 500-mL HDPE Bottle	2x 1-L HDPE Bottle	100 mL HDPE sample vial	100 mL HDPE sample vial
Sample Site Code – Sample Media Code – Sample Number	0 to 6 ft bgs	Determine chemical and physical characteristics of porewater	Visual Characterization/Water Quality Meter (pH, turbidity, conductivity, temperature, ORP, dissolved oxygen, etc)/Iron (III) Test Kit						
Field Sampling									
			total field samples	16	16	16	16	16	16
			total field duplicates	1	1	NA	1	1	1
			total field/rinsate blank5[5]	4	NA	NA	NA	NA	NA
			total temperature blanks (not analysis-specific)	2	NA	NA	NA	NA	NA
			total laboratory QC duplicate/MS/MSD[3]	1	1	NA	NA	NA	NA
			Total Analyses for EPA-certified Lab	24	18	16	17	17	17

Table 5-3b Notes:

[1] EPA 6010 (ICP-AES) will be used for TAL metals analysis if there are high concentrations of trace elements in the sample.

[2] 1-L HDPE Narrow Mouth bottle with F-217 LDPE foam liners.

[3] Samples for laboratory QC will be designated in the field, one MS/MSD per 20 samples. No extra sample material will be necessary for this sample, the 1-L HDPE bottle containing the sample should be sufficient for analyzing the field sample and the MS/MSD.

[4] Harkins, S.A., Appold, M.S., Nelson, B.K., Brewer, A.M., and Groves, I.M., 2008, “Lead isotope constraints on the origin of non-sulfide zinc and sulfide zinc-lead deposits in the Flinders Ranges, South Australia”: *Economic Geology*, v. 103, pp. 353-364.

[5] At least 1 rinsate blank sample per day of field work will be collected to ensure decontamination measures are working.

Table 5-3b Key:

AES	Atomic Emission Spectroscopy	Hg	Mercury	MS	Mass Spectrometry	TAL	Target Analyte List
bgs	below ground surface	ICP	Inductively Coupled Plasma	MS/ MSD	Matrix Spike / Matrix Spike Duplicate	TOC	Total Organic Carbon
°C	Degree Celsius	ID	Identification	NA	Not Applicable		
EPA	Environmental Protection Agency	L	liter	ORP	Oxidation reduction potential		
ft	Feet	LDPE	Low-density polyethylene	QA	Quality Assurance		
HDPE	High-density Polyethylene	MS	Matrix Spike	QC	Quality Control		

Table 5-4b. Analytical Sensitivity and Project Criteria

Parameter	Method	Reporting Limit (RL)	MS Recovery Limits (%)	MS/MSD or Laboratory Duplicate RPD Limits (%)	Field Duplicate RPD Limits (%)
TAL metals	EPA Method 6020, 7471A (Hg)	See Table 5-5	75-125	≤ 20	≤ 50
Stable Lead Isotopes	Harkins et al (2008)[2]	NA	NA	NA	NA
Ferrous Iron	1,10-phenanthroline method[3]	0.2 to 10 mg/L	NA	NA	NA
pH	TBD	pH 0 to 14	NA	NA	NA
Dissolved Oxygen		0 to 50 mg/L	NA	NA	NA
Conductivity		0 to 10 S/m	NA	NA	NA
Temperature		0 to 55 °C	NA	NA	NA
Turbidity		0 to 800 NTU	NA	NA	NA

Table 5-4b Notes:

[1] Plumb, R. H. Jr., Procedures for Handling and Chemical Analysis of Sediment & Water Samples, May 1981, USACE Publication AD/A103788

[2] Harkins, S.A., Appold, M.S., Nelson, B.K., Brewer, A.M., and Groves, I.M., 2008, "Lead isotope constraints on the origin of non-sulfide zinc and sulfide zinc-lead deposits in the Flinders Ranges, South Australia": *Economic Geology*, v. 103, pp. 353-364.

[3] American Public Health Association, 1992. *Standard Methods for the Examination of Water and Wastewater: 11th Edition*, Washington D.C., p. 522.

Table 5-4b Key:

°C	Degree Celsius	NTU	Nephelometric Turbidity Units
EPA	Environmental Protection Agency	RL	Reporting Limit
Hg	Mercury	RPD	Relative Percent Difference
mg/L	Milligrams per liter	S/m	Siemens per meter
MS	Matrix Spike	TAL	Target Analyte List
MSD	Matrix Spike Duplicate	TBD	To be determined by analytical laboratory
NA	Not Applicable		

Table 5-5. Method Reporting Limits for TAL Metals and Silicon by EPA SW-846 Method 6020

Analyte	Method Reporting Limit	
	Sediment	Water
	mg/kg	ug/L
Aluminum (Al)	5.5	55
Antimony (Sb)	0.20	0.2
Arsenic (As)	0.10	1.0
Barium (Ba)	0.50	0.3
Beryllium (Be)	0.20	0.2
Cadmium (Cd)	0.05	0.2
Calcium (Ca)	10	100
Chromium (Cr)	0.20	0.6
Cobalt (Co)	0.20	0.3
Copper (Cu)	0.10	0.4
Iron (Fe)	10	100
Lead (Pb)	0.50	0.2
Magnesium (Mg)	10	100
Manganese (Mn)	0.20	1
Mercury (Hg)	0.05	0.3
Nickel (Ni)	0.10	0.5
Potassium (K)	50	500
Selenium (Se)	0.50	1
Silicon (Si)[1]	5	60
Silver (Ag)	0.10	0.2
Sodium (Na)	10	100
Thallium (Tl)	0.20	0.2
Vanadium (V)	0.10	0.5
Zinc (Zn)	0.40	1.5

Table 5-5 Notes:

[1] Si method reporting limits are for EPA Method 6010B.

5.4 Data Assessment

5.4.1 Data Quality Objectives and Criteria for Data Measurement

DQOs are the quantitative and qualitative terms used to describe the quality and quantity of the data needed to meet the objectives of the project. DQOs are developed by considering the purpose of collecting the data and its intended use.

The objective of the UCR In-Situ Porewater Assessment is to characterize contaminant concentrations and lead isotopic ratios within porewater at locations along the UCR. To this end, the goals of this study are to:

1. Obtain information on the concentration of dissolved and total metals in porewater in areas of slag deposition beneath the groundwater/surface water interface;
2. Obtain information on the general chemistry of porewater in areas of slag deposition; and
3. Assess the practicability of obtaining a lead isotopic signature from porewater.

Other objectives of the study include evaluating diurnal flow effects on porewater quality and assessing differences in porewater quality as locations move downstream.

EI has determined that four or more sites along the UCR will be sampled to satisfy the data quality objectives. The actual number and location of samples may vary based on field conditions. If any of the physical constraints are present making it unreasonably difficult or dangerous to collect a sample, the site will not be sampled.

Field conditions, including high river levels, may exclude some locations for which porewater samples have been proposed. River levels in the UCR are lowest between January and April but areas of interest may still be accessible throughout June. Sampling shall be attempted during this time period to ensure maximum possible success.

DQOs for measurement data (referred to here as data quality indicators) are precision, accuracy, representativeness, completeness, comparability, and measurement range. The overall QA objective for analytical data is to ensure that data of known, acceptable, and legally defensible quality are generated. To achieve this goal, data must be reviewed for 1) precision, 2) accuracy or bias, 3) representativeness, 4) comparability, and 5) completeness.

A summary of DQOs developed to meet the goals of the UCR In-Situ Porewater Assessment are presented in **Table 5-4**. Data validation to ensure QA/QC measures have been met is discussed in further detail in Section 5.4.1.6.

5.4.1.1 Precision

Precision measures the scatter in the data due to random error. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. Analytical precision is measured through MS/MSD samples for organic analysis and through laboratory duplicate samples for inorganic analyses. Analytical precision is quantitatively expressed as the relative percent difference (RPD) between the MS/MSD or duplicates.

Field and analytical precision will be evaluated by the RPD between field duplicate samples and laboratory duplicate samples; laboratory accuracy and precision will be determined by the spike recoveries and the RPDs of the MS/MSD samples, respectively.

$$RPD = \frac{(R1 - R2)}{((R1 + R2)/2)} \times 100$$

R1 = Recovery for MS or initial analyte concentration
R2 = Recovery for MSD or duplicate sample concentration

Precision criteria for this study are analytical parameter-dependent, and are listed in Table 5-3.

5.4.1.2 Accuracy

Accuracy measures the closeness of the measured value to the true value. Analytical accuracy is assessed by "spiking" samples with known standards (surrogates or matrix spikes) and establishing the percent recovery. When a known amount of surrogate is added to a sample and its percent recovery is within laboratory established control limits, then the analyte values in the sample are considered accurate.

Accuracy will be evaluated by the use of percent recovery of the target analyte in spiked samples and surrogates in all samples and QC samples.

$$\%\ Recovery = \frac{SQ - NQ}{S} \times 100$$

SQ = quantity of spike or surrogate found in sample
NQ = quantity found in native (unspiked) sample
S = quantity of spike or surrogate added to native sample

5.4.1.3 Representativeness

Representativeness is the degree to which data from the project accurately represent a particular characteristic of the environmental matrix that is being tested. Representativeness of samples is ensured by adherence to standard field sampling protocols and standard laboratory protocols.

The design of the sampling scheme and number of samples should ensure the representativeness of each matrix or product of the chemical processes being sampled.

5.4.1.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. The use of standard techniques for both sample collection and laboratory analysis should make data collected comparable to both internal and other data generated. Sample collection methods and other field methods are described in Section 5.3.

Comparability is the measurement of the confidence in comparing the results of this study/project with the results of a different study/project using the same matrix, sample location, sampling techniques and analytical methodologies.

5.4.1.5 Completeness

Completeness is defined as the ratio of acceptable (non-rejected) measurements obtained to the total number of measurements for an activity. The completeness objective for this project is 100 percent.

Completeness is the percentage of valid results obtained compared to the total number of samples taken for a parameter. Since sampling is by grabs and limited in number of samples, the number of valid results obtained from the analyses are expected to be equal or better than 90%. Percent completeness may be calculated using the following formula:

$$\% \text{ Completeness} = \frac{\#\text{ of valid results}}{\#\text{ of samples collected}} \times 100$$

The QA objectives outlined, above, will be evaluated in conjunction with the data validation process.

5.4.1.6 Data Review, Verification, and Validation

All of the data received from each laboratory will be subject to validation at a Level 2 review. The Level 2 review includes verifying the following:

- The laboratory utilized the specified extract, analysis, and cleanup methods.
- The sample holding time was not exceeded.
- Sample numbers and analyses match those requested on the chain-of-custody.
- Required reporting limits have been achieved.
- Surrogate compound analyses have been performed and have met QC criteria.
- Initial and continuing calibrations were run at the proper frequency and met acceptance criteria.
- Laboratory blanks are free of contaminants.

Data found to have significant deficiencies may be validated in accordance with EPA's functional guidelines for data validation (EPA 2004) by EI or others. Following this review, data qualifiers assigned by the laboratory may be amended.

5.4.1.7 Corrective Action

If procedures in the field or the lab are not performed to the project specifications and data quality objectives are not met, specific corrective actions will be determined that may include but are not limited to the following:

- Identifying the source of the violation,
- Re-analyzing samples if holding time criteria permit,
- Re-sampling and analyzing,
- Evaluating and amending sampling and analytical procedures, and
- Accepting data and flagging it to indicate the level of uncertainty.

5.4.2 Data Evaluation

Comparison of measured concentrations with risk-based sediment criteria is not an objective of this study; however, analytical methods shall be selected to ensure that method detection limits are sufficiently low to quantify measured concentrations below CCT sediment cleanup levels and Ecology freshwater sediment quality standards.

5.5 Decontamination

Non-dedicated sampling equipment such as porewater sampling devices, sediment core samplers, sampling scoops, and other reusable equipment that come into contact with sample material will require decontamination between sample locations. Decontamination procedures will be performed in accordance with ***EI SOP No. 1008 – Field Equipment Decontamination*** in Appendix A.

5.6 Location & Elevation Survey

All porewater sample locations will be surveyed for horizontal location using a handheld GPS Unit. Field survey data presented by the GPS unit will clearly list the coordinates (and system) and relative elevation, as appropriate for all surveyed locations. The vertical position of each sample will be measured by using a ruler or tape measure with a minimum of 1-centimeter measurement marks and then recorded in the field log book. The location and elevation survey will be used to develop maps and graphics for the project summary report.

5.7 Investigation-Derived Waste Handling

IDW generated during the field activities performed during this investigation include porewater sample tubing, personal protective equipment, and decontamination fluids. A small amount of contaminated sediment may be included with the IDW. IDW will be handled in accordance with ***SOP No. EI-4033 – Investigation-Derived Waste Handling*** provided in Appendix A.

IDW is expected to consist of disposable sampling supplies (gloves, paper towels, etc.) that will be placed into garbage bags at each sampling site then disposed of as solid waste at a municipal waste landfill. Decontamination fluids will not be contained as the volume and contaminant concentrations are not expected to be significant. Excess sample material not packaged for analysis will be left on site in the area that it was collected from. It will be the responsibility of each subcontracted laboratory to dispose of excess material not used during chemical and physical analysis in accordance with appropriate regulations. However, each subcontracted laboratory shall not dispose of the sample material until directed to do so by EI.

5.8 Sample Handling and Custody

Samples collected during this study will be stored in coolers and kept under custody at all times. A Chain-of-Custody (COC) form will be completed in indelible ink for each shipping container used. Each sample will be included in the field data sheets and given individual numbers to match the bottles and the field data sheets. Prior to sealing the sample shipping container, one copy of the COC form and a copy of the field record sheet will be sealed in a re-sealable waterproof plastic bag. This plastic bag will be taped to the inside cover of the sample shipping container so that it is maintained with the samples being tracked. Ice chests will be sealed with reinforced tape for shipment. Until the field samples are relinquished to the laboratory, the samples will be kept in coolers with ice and cooled to approximately 4 °C. Each cooler will have an accompanying temperature blank. Chain-of-custody and sample labeling documentation procedures are detailed in ***SOP No. EI-1004 – Chain-of-Custody and Sample Labeling***.

5.9 Data Management & Documentation Procedures

Data generated as part of this project will be maintained in an organized manner in the field, at the analytical laboratory, and during reporting to minimize data interpretation errors and omissions.

5.9.1 Field Data Management and Documentation

Field data management and documentation including field log books and sample collection forms will be performed in accordance to ***SOP No. EI-4014 – Field Documentation and Forms***. Chain-of-custody and sample labeling documentation procedures are detailed in SOP No. EI-1004. Both SOPs are included in Appendix A. The SOPs also include the relevant field forms. All field data management and documentation are subject to possible QA audit assessment.

5.9.2 Laboratory Data Management and Documentation

The laboratory will provide a *Level B* data package deliverable, which will include:

- Project narrative;
- Sample results sheets;
- Chain-of-custody and sample receipt documentation;
- Initial and continuing calibration summary sheets, if available and when appropriate to meet project-specific requirements;
- Instrument performance verification (Gas Chromatograph/Mass Spectrometer tunes, interference check samples, retention time shift checks), as appropriate for the specific method;
- Surrogate and internal standard data, as appropriate for the specific method; and
- Field and laboratory QC samples results including blank, matrix spike, laboratory control sample, and duplicate results.

Data packages will be provided for all samples analyzed and these will be maintained as a permanent record in the project file.

5.9.3 Reporting Data Management and Documentation

All laboratory data will be tabulated in an electronic format (typically Microsoft Excel or Microsoft Access) and any data qualifiers needed as a result of the data evaluation (Form R) will be included. To minimize potential for transcription errors, sample results will be electronically downloaded directly and verified against the hardcopy data packages. The data will be verified by comparing the electronic data printouts to the hardcopy laboratory data package results and the qualifications made in the data evaluation reports. This verification is performed to detect and correct errors, and to prevent the loss of data during data reduction, data reporting, and data entry into forms/reports/databases.

Electronic and database files will be maintained as a permanent record in the project file. Summary data tables and graphics generated from the electronic laboratory data will be included in the final assessment or investigation report.

The project file will be maintained for the life of the contract and provided upon request to the CCT, the State of Washington, or the attorneys representing same. The project file will be archived in accordance with contract requirements.

6. REFERENCES

Dowling, Brendan, August 2007. *Field Reconnaissance and Sediment Sampling Report – Upper Columbia River Site, Washington*. Prepared for the Washington Department of Ecology, Toxics Cleanup Program, Eastern Regional Office, Spokane, WA.

Harkins, S.A., Appold, M.S., Nelson, B.K., Brewer, A.M., and Groves, I.M., 2008, "Lead isotope constraints on the origin of non-sulfide zinc and sulfide zinc-lead deposits in the Flinders Ranges, South Australia": *Economic Geology*, v. 103, pp. 353-364.

Northwest Hydraulic Consultants (NHC), April 10, 2007, *Columbia River Substrate Investigation – Final Report*, prepared for BC Ministry of Environment Aquatic Ecosystems Research Lab, BC Hydro and Power Authority, and Columbia River Integrated Environmental Monitoring Program by Northwest Hydraulic Consultants, Ltd.

Paulson, Anthony J. and Stephen E. Cox. 2007. "Release of elements to Natural Water from Sediments of Lake Roosevelt, Washington, USA". *Environmental Toxicology and Chemistry*, Vol. 26, No. 12, pp. 2550-2559.

United States Environmental Protection Agency (EPA), December 2008a, *Upper Columbia River Work Plan for the Remedial Investigation and Feasibility Study*, modified by the US Environmental Protection Agency, based on the Draft Work Plan Provided by Teck Cominco American Incorporated.

_____, 2004, *Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA, Office of Solid Waste and Emergency Response, Document No. EPA 540/R-04-004, Washington D.C.

United States Geological Survey (USGS), 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*, Water Resources Investigations Report 03-4170, prepared in cooperation with the Confederated Tribes of the Colville reservation, Lake Roosevelt Water-Quality Council, Bureau of Reclamation, and National Park Service.

Washington State Department of Ecology (Ecology), April 2009. *High-resolution Porewater Sampling near the Groundwater/Surface Water Interface*, Publication No. 09-03-017. Prepared by Charles Pitz, Licensed Geologist/Licensed Hydrogeologist for Ecology's Environmental Assessment Program, Olympia, WA.

_____, June 2008a, *Summary of Sediment Sampling Activities to Support Preliminary Benthic*

Invertebrate Colonization Studies of Lake Roosevelt Sediments. Technical Memorandum prepared by Washington State Department of Ecology, Toxics Cleanup Program, Eastern Regional Office, Spokane, WA.

______, March 6, 2008b. *Upper Columbia River – Black Sand Beach Proposal to Conduct Static Acute Fish Toxicity Tests*.

Appendix A

Standard Operating Procedures

EI SOP No. 1003 – SEDIMENT COLLECTION AND SAMPLING

Written By:	**Approved By:**	**Date:**	**QA Concurrence**	**Date :**
Suzanne Dolberg	Craig Christian	3/3/2010		3/3/2010

This Standard Operating Procedure (SOP) contains 10 sections:

1. Purpose

The purpose of this SOP is to provide field personnel with a set of guidelines for collecting sediment and sediment samples. This SOP covers use of the most common sediment collection equipment and sediment sampling techniques. The sediment sampling techniques listed in this SOP are not intended to be all inclusive. Consult the site-specific Sampling and Quality Assurance Plan (SQAP) for specific sample collection requirements or techniques not directly covered in this SOP.

2. Application

The procedures outlined in this SOP can be used by field personnel for the collection of sediments consisting of soft fine-grained material, silts and clays, or sands and gravels, from streams, rivers, or standing water bodies.

3. References

American Society for Testing and Materials (ASTM). March, 2005. “Standard Practice for

Sampling Soils and Contaminated Media with Hand-Operated Bucket Augers”. ASTM Standard D-6907-05. ASTM International, West Conshohocken, PA.

Simmons, Kevin. 2007. Sediment Sampling. U.S. Environmental Protection Agency Region 4, SESDPROC-200-R1. November.

EPA. SOP# 2016, Revision #0.0. Sediment Sampling. November 17, 1994.

4. Associated SOPs

EI-1002:	Surface Water Collection & Sampling
EI-1004:	Chain of Custody & Labeling
EI-4014:	Field Documentation
EI-4028:	Soil Sample Collection for Volatile Organics
EI-4033:	Investigation-Derived Waste Handling
EI-4034:	Environmental Sample Packing and Shipping

5. Equipment

The following equipment can be used in various field conditions for sediment collection:

- Documentation such as the field log book, field forms, and chain of custodies
- Copy of the Field Sampling Plan, Health and Safety Plan, and Quality Assurance Plan
- Site diagrams indicating sample locations
- PPE required per the HSP or SAP based on site hazards
- Nitrile Gloves
- Stainless steel mixing bowl
- Stainless steel spoon
- Stainless steel trowel
- Stainless steel hand auger
- Stainless steel ponar dredge
- Nylon rope
- Waterproof boots, hip or chest waders
- Position location equipment such as location buoys, flagging tape, wooden stakes, global positioning system (GPS)
- Decontamination equipment and supplies
- Sample bottles and containers and specified in the site-specific SAP
- Cooler and ice for samples
- Folding ruler with 0.01-ft increments

- Geologic characterization equipment: Munsell color chart, USCS
- Handheld photoionization detector (PID) or handheld X-Ray Fluorescence (XRF) spectrometer or both
- Digital Camera with Time/Date Stamp option turned on

6. Decontamination

All non-disposable equipment that comes in contact with sediment and surface water will be decontaminated prior to arrival on site, between sampling locations, and before leaving the site. Decontamination procedures will be followed in accordance with EI-1008.

7. Equipment Selection and Sampling Considerations

The type of equipment used for the collection of sediment is determined by the sampling objective such as surface versus subsurface samples and site restraints such as water depth and conveyance. The methods discussed for collecting sediment from a water body or other surface water conveyance are:

- Spoons or scoops
- Coring devices
- Ponar Dredge

Some considerations when collecting sediment samples are:

- Contaminants are more likely to concentrate in depositional areas of streams where the sediments are characterized by fine particle size and high organic matter content.

- If wading in a stream or river, sampling should proceed from downstream to upstream with the sample collected facing upstream.

- Most biological activity occurs within the top 10 centimeters of sediment. If collecting samples to assess ecological risk, sediment should be collected from the top 10 centimeters.

- Loose organic debris should be removed from the sample location prior to sampling.

- Any organic debris which is representative of the depositional environment will remain as part of the sample with the approximate percentage of organic material recorded.

- Any stones or gravel will be removed from the sample after a relative percentage of the stones or gravel has been recorded in the logbook.

- Take precautions to ensure that the sediment sample collected is representative of the water body or conveyance.

- If also collecting surface water samples, collect them prior to collecting the sediment sample. See SOP EI-1002 for surface water sampling procedures.

- Always use the buddy system and have a co-worker with you at all times.

- Always document in the site logbook how each sample is collected. Also document each sample location photographically.

8. Sediment Collection Procedures

8.1 Spoon or Scoop

Spoon or scoop sampling should be used in shallow (> 6-inches) onshore locations, low flow shallow streams, or areas where the conveyance is dry and the sediment is easily accessible.

When sampling multiple locations, begin sampling at the most downstream location and work upstream to the final sample location. If wading into a shallow stream or conveyance, wade in facing upstream ensuring minimal disturbance to the sediment.

A decontaminated stainless-steel spoon or scoop is inserted into the sediment and scooped up in an upstream direction. The sample is placed in its appropriate sample container or transferred to a mixing bowl for homogenization. Surface water should be decanted from the sample or homogenization container with care taken to ensure the fine sediment fraction is retained. Care should be taken to ensure that fine-grained particle size materials associated with the sediment being sampled are not lost in excess water drainage. **NOTE**: If the sample's pore water is also being analyzed, do not decant the surface water from the sediment sample.

When sampling for volatile organics analysis, the aliquots should be handled as little as possible to prevent the loss of volatiles.

Decontaminate the spoon or scoop prior to collecting the next sample. Decontamination shall be conducted in accordance with SOP-EI-1008.

Sediment sampling horizontal coordinates can be collected using a GPS or the locations can be located using a GPS.

8.2 Coring Devices

Sediment corers should be used in place of spoon or scoop sampling equipment when the water depth is greater than six inches or the rate of stream flow will cause disturbance or loss to fine-grained particle size materials associated with the substrate being sampled. The tube or bucket auger is driven into the sediment and used to extract a core and can be used at various water depths with the use of additional extensions and a T-handle.

Tube Auger

Bucket Auger

An acetate core liner can also be used by inserting into either the tube or bucket auger prior to sampling to extract an intact sediment core.

Again, when sampling multiple locations, begin sampling at the most downstream location and work upstream to the final sample location. If wading into a shallow stream or conveyance, wade in facing upstream ensuring minimal disturbance to the sediment.

The following procedures should be used to collect a sediment sample with either the tube or bucket auger:

1. Determine the sediment depth below water and attach the appropriate number of extensions along with the T-handle. Insert acetate liner if required.
2. Clear the area to be sampled of any debris without disturbing the sediment.
3. Insert the tube or bucket auger into the sediment at an angle 0° to 20° from vertical in order to minimize spillage of the sample from the sampling device upon retrieval.

4. Rotate the auger while applying pressure to cut a core of sediment.

5. Slowly withdraw the auger making sure the sediment core is intact. With the tube auger, make sure the slot is facing upward.

6. If field screening the samples for the presence of metals or VOCs, conduct the field screening prior transferring samples into the sample containers. Field screening shall be performed in accordance with the equipment manufacturer's instructions. If screening for VOCs, headspace screening will be performed in accordance with SOP EI-4019.

7. Transfer the sample into the appropriate sample container or mixing bowl for homogenization. If using an acetate liner, the liner can be capped at both ends and transported to the laboratory or the sediment can be removed from the acetate liner and homogenized and collected. If capping the acetate liner, simply remove the liner from the sampling device, cut off the acetate tube where headspace is present, and cap at both ends. Indicate on the outside of the acetate liner the appropriate orientation of the core. If sampling the sediment simply remove the acetate liner from the sampling device and using a razor or carpet knife, cut the liner lengthwise in two places allowing for the sediment to be exposed. The sediment can then be removed from the liner into a stainless steel mixing bowl for homogenization or transferred directly into the sampling containers. **NOTE**: Samples collected for volatile organic analysis must be collected prior to homogenization following the procedures outlined in SOP EI-4028.

8. Record in the field log book or sediment sampling field form (see attached), the length of the core and a description of the sediment using the USCS system and guidelines outlined in SOP EI-4014.

9. Decontaminate all the sampling equipment following the guidelines outlined is SOP-EI-1008.

10. If necessary, identify the location with a wooden stake, flagging tape, or marker buoy for future reference. Sediment sampling horizontal coordinates can be collected using a GPS or the locations can be located using a GPS.

8.3 Ponar Dredge

A ponar dredge is used to collect surface sediment at a sediment depth ranging from 0 to 4 inches by activating spring-loaded jaws which entrap the sediment. A ponar dredge can be used in deep water with the use of a winch or shallow waters as a handheld device.

Ponar Dredge

Ponar dredge using a winch

The collection of surface sediment is accomplished by lowering the ponar dredge to the surface of the sediment with the use of a rope or cable or an extended handle and activating the opened spring-loaded jaws to a closed position. The weight of the ponar dredge along with the spring loaded closing action allows for the collection of surface sediment. When used as a handheld device, the dredge can be placed on the sediment surface and activated.

Again, when sampling multiple locations, begin sampling at the most downstream location and work upstream to the final sample location. If wading into a shallow stream or conveyance, wade in facing upstream ensuring minimal disturbance to the sediment.

The following procedures should be followed to collect a surface sediment sample using a ponar dredge:

1. Attach a nylon rope or steel cable to the stainless steel ring fixed to the top of the ponar dredge.

2. Arrange the ponar dredge with the jaws in the open position and insert the spring-loaded pin into the hole in the trip bar.

3. Slowly lower the ponar dredge to approximately 2 inches above the sediment, making sure the rope or cable is taut at all times. Any slack may release the spring-loaded pin and close the ponar dredge before it has immersed into the sediment.

4. Drop the ponar dredge into the sediment and give the rope or cable some slack. This will release the spring-loaded pin which will activate the trip bars and close the ponar dredge. Pull up sharply on the rope or cable a few times to ensure the spring-loaded pin has released.

5. Pull the rope or cable taut and raise the dredge to the surface allowing any free liquid to decant from the screens on top of the dredge. Care should be taken to retain the fine sediment fraction during the decanting process.

6. Open the dredge over a stainless steel bowl and transfer the sediment from the dredge to the bowl.

7. If field screening the samples for the presence of metals or VOCs, conduct the field screening prior transferring samples into the sample containers. Field screening shall be performed in accordance with the equipment manufacturer's instructions. If screening for VOCs, headspace screening will be performed in accordance with SOP EI-4019.

8. Transfer a sample into the appropriate sample container or homogenize the sample and place into appropriate sample containers. Samples collected for volatile organic analysis must be collected prior to homogenization following the procedures outlined in SOP EI-4028.

9. Record in the field log book or sediment sampling field form (see attached), a description of the sediment using the USCS system and guidelines outlined in SOP EI-4014.

10. Decontaminate all the sampling equipment following the guidelines outlined is SOP-EI-1008.

11. If necessary, identify the location with a wooden stake, flagging tap, or marker buoy for future reference. Sediment sampling horizontal coordinates can be collected using a GPS or the locations can be located using a GPS.

9. Documentation

A Sediment Sampling Log must be completed for each sediment location sampled. See Attachment 1.

10. Measure of Proficiency

Field staff will demonstrate proficiency by successfully completing Sections 6 through 9 a minimum of three times under the direct supervision of a Senior Associate with appropriate field experience or their designee

Attachment 1: Sediment Sampling Log Sheet

Sediment Location	
Sediment Sample ID	
QC IDs (if applicable)	
Collection Method	
Sample Depth	
Sample Date/Time	
Sampler	
Photo Number	
Analyses	
Sediment Appearance	
Munsell Color	
Consistency	
Grain Size	
Debris Present (circle all that apply)	**Leaves Twigs Rocks Mussels Shells Trash Seaweed** **Other:** ____
Describe Debris	
Odor (if applicable)	
Sheen (if applicable)	

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for installing, measuring, and decommissioning hand-driven in-water piezometers

Version 1.0

Authors – Kirk Sinclair and Charles Pitz
Date-

Reviewer - Martha Maggi, Groundwater/Forests & Fish Unit Supervisor
Date -

QA Approval - William R. Kammin, Ecology Quality Assurance Officer
Date -

EAP061

APPROVED:

Signatures on file

The Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows this SOP in most cases, there may be situations where an alternative methodology, procedure, or process is employed to meet specific project objectives. In such cases the project manager is responsible for documenting significant deviations from these procedures in the formal study report.

Revision History

Date	Revision number	Summary of change(s)	Revised section(s)	Reviser(s)

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LIST OF FIGURES

Environmental Assessment Program

Standard Operating Procedures for Installing, Measuring, and Decommissioning Hand-Driven In-Water Piezometers

1.0 Purpose and Scope

1.1 The Environmental Assessment Program (EAP) is responsible for measuring, assessing, and reporting information about the environmental condition and health of Washington's land and water resources. This information is used by resource managers, policymakers, and others to help protect and manage Washington's environment. As such there is a need to document and ensure that consistent and scientifically defensible practices, procedures, and techniques are used by EAP staff, and that the data and information they provide are of consistent and high quality.

1.2 This SOP summarizes the general procedures and practices EAP staff use to install, measure, and remove hand-driven piezometers along streams, rivers, or other water bodies and is one of several documents developed to memorialize the program's standard operating procedures and practices.

1.3 Staff deploying or monitoring in-water piezometers should also consult and follow EAP's companion documents and SOPs that describe the use of GPS instruments (EAP013 - Janisch, 2006), stream temperature monitoring (EAP0044 - Bilhimer and Stohr, 2007), performing manual depth to groundwater measurements (EAP052 - Marti, 2009), hydraulic test procedures (Pitz, 2006), and groundwater sampling (under development).

2.0 Applicability and Background

2.1 In-water piezometers are one of several tools used by EAP to help define the distribution, timing, volume, and quality of groundwater that discharges to streams, lakes, and other water bodies. In this context piezometers serve several important roles. They can be used to:

2.1.1 Estimate hydraulic conductivity values for streambed, lakebed, or other sediments,

2.1.2 Measure the vertical hydraulic gradient between a surface water body and near-surface groundwater,

2.1.3 Monitor sediment thermal profiles, and

2.1.4 Sample groundwater quality.

2.2 Detailed knowledge of these factors is important for total maximum daily load (TMDL) investigations or other studies where an understanding of local surface water/groundwater (SW/GW) interactions is important.

2.3 For ease of presentation the discussion that follows centers around piezometer deployments in streams or lakes. However, these techniques and tools can easily be adapted to assess SW/GW interactions within wetland, estuarine, or marine environments.

2.4 This document supplements but does not replace the need for on-the-job training. When in doubt seek additional guidance.

3.0 Definitions

3.1 Constant Head Injection Test (CHIT) – A procedure whereby the bulk hydraulic conductivity of streambed or other "in-water" sediments are evaluated by injecting water into a piezometer at a rate sufficient to maintain a constant pre-determined water level (or head) in the piezometer (see Cardenas and Zlotnik, 2003; and Pitz, 2006 for additional details regarding the theoretical basis for these tests and the standard field procedures EAP uses to conduct them).

3.2 Development (of piezometers) – The process of removing fine sediment that accumulates within the casing or open interval of a piezometer during installation. Development is typically accomplished using a combination of jetting, surging, and pumping.

3.3 DNR – Washington Department of Natural Resources

3.4 EAP – Environmental Assessment Program

3.5 Ecology – The Washington State Department of Ecology

3.6 EIM – Environmental Information Management System. Ecology's database of environmental information.

3.7 Global Positioning System (GPS) receiver – An instrument capable of receiving signals from the U.S. Department of Defense Global Navigation Satellite System. GPS receivers use these signals to determine their current geographic location, the time, and their velocity.

3.8 In-Water Piezometer – A small-diameter observation well installed directly into a surface water body to monitor depth to groundwater, sediment water temperatures, sediment hydraulic properties, and/or to periodically collect groundwater quality samples.

3.9 Land Surface Datum (LSD) – a datum plane that is approximately at land surface at each well. If known, the elevation of the land-surface datum relative to a standard geodetic datum (such as NGVD 1929 or NGVD88) is given in the well description.

3.10 Water Level Measuring Point (MP) – The point on an in-water piezometer (typically the top of casing) from which depth-to-water and surface water stage measurements are made. Unlike the piezometer reference point which is fixed (see below), the position of the water level measuring point can vary over time as extensions are added to or removed from a piezometer to accommodate project needs or changing surface water conditions.

3.11 Open Interval – The portion of a piezometer pipe that is perforated or screened to allow water entry into the casing. The open interval is typically described based on its overall length and position relative to the piezometer reference point (see below).

3.12 Pressure transducer - An instrument that can be programmed and deployed to measure and record water pressures at a defined time interval.

3.13 Quality Assurance Project Plan (QAPP) – A written plan that describes how a study will be conducted and its results assessed.

3.14 Permanent Reference Point (PRP) – A permanent (fixed) reference point on a piezometer casing that is used to measure a piezometer's physical characteristics (such as the total installation depth or position of the open interval) with respect to the sediment surface.

3.15 Sediment – A generic term used to describe the surficial materials (especially sand, gravel, silt, and clay) that typically mantle the bed of streams, rivers, lakes, or other water bodies – and into which in-water piezometers are driven.

3.16 Static Water Level (SWL) – The level to which water in a well casing naturally rises in the absence of external stresses (such as the withdrawal or injection of water locally or in nearby wells).

3.17 Stilling tube – A short length of perforated-translucent tube used to measure the position of the water surface in rivers, lakes, or other water bodies. Stilling tubes help to stabilize the water surface by minimizing short-term instabilities arising from turbulence, pressure waves, or other factors.

3.18 Stream seepage evaluation – A study conducted to define the relative stream-flow gain from or loss to groundwater along a stream reach.

3.19 Surface water stage (as measured using an in-water piezometer) - The position (level) of the water surface in a stream, lake, or other water body with respect to the piezometer water level measuring point (see Figure 6).

3.20 Thermistor (recording) – A programmable instrument that can be deployed to measure and record the temperature of water, air, or other media at a user-defined time interval.

3.21 Total Maximum Daily Load (TMDL) (study) – A study conducted to define the maximum potential contaminant load (for specific parameters of concern) that a water body can assimilate without violating water quality standards.

3.22 Vertical Hydraulic Gradient (as measured using an in-water piezometer) – The difference in total head between a surface water body and groundwater divided by the distance between the sediment surface and the midpoint of the piezometer perforations.

4.0 Personnel Qualifications/Responsibilities

4.1 All staff who deploy or monitor in-water piezometers are responsible for complying with this SOP and the requirements of the EAP safety manual - particularly Chapter 1 ‘General Field Work’ and the following sections of Chapter 2: ‘Measuring Flows in Rivers and Streams’, ‘Groundwater Sampling and Water-Level Measurements’, ‘Using Hand or Power Tools’, and ‘Using Brush Cutters and Trimmers’ (Ecology EAP, 2009).

4.2 The Water Well Construction Act of 1971 (Chapter 18.104 RCW) requires that a licensed well driller or engineer be present at all times to oversee piezometer installation or decommissioning activities. The driller/engineer must also sign and submit well drilling notice of intents, well completion reports, and other associated paperwork to Ecology’s Water Resources Program within the timelines specified in Chapter 173-170 WAC (Minimum Standards for Construction and Maintenance of Wells) (see Appendix B for details).

4.3 When conducting field work via a boat, at least one crew member must be a qualified boat operator (per interim Ecology Policy 11-60). All crew members are responsible for reading and following the general boating guidance in the EA Safety Manual (Chapter 3).

4.4 The field lead is expected to have a detailed working knowledge of the project Quality Assurance Project Plan (QAPP) and is responsible for ensuring that other field staff are briefed on the study goals and objectives and that they adhere to prescribed sampling methods while conducting field work.

5.0 Equipment and Supplies

5.1 Personal Field Gear

5.1.1 a small backpack
5.1.2 rain gear top and bottom
5.1.3 hearing protection
5.1.4 eye protection
5.1.5 hardhat
5.1.6 hip/chest waders with wading boots

5.1.7 leather gloves
5.1.8 Sun hat
5.1.9 Extra warm non-cotton clothing
5.1.10 personal flotation device
5.1.11 sunscreen
5.1.12 filled water bottle and extra food

5.2 Portable Field Toolbox

5.2.1 two pipe wrenches
5.2.2 hammer and assorted nails
5.2.3 knife
5.2.4 screwdriver set with commonly used head types and sizes
5.2.5 assorted stainless steel screws, nuts, and bolts
5.2.6 duct tape
5.2.7 assorted pliers
5.2.8 100 - foot coil of 12 to 14 gage aluminum or galvanized wire
5.2.9 100 - foot coil of 18 to 20 gage aluminum or galvanized wire
5.2.10 ¼ - inch standard and metric socket set plus assorted stainless nuts and bolts
5.2.11 crescent wrenches
5.2.12 plumber’s tape
5.2.13 wire clippers
5.2.14 12-foot engineer’s hand tape
5.2.15 wire-reinforced zip ties, various lengths
5.2.16 extra piezometer caps, plugs, and couplers
5.2.17 indelible ink pen

5.3 Piezometer Installation and Development

5.3.1 Appropriate piezometer materials (such as pre-fabricated galvanized steel or PVC piezometer pipes, pipe couplers, extensions, and caps/plugs; or flexible-poly tubing with drive rod assembly and drive point).
5.3.2 Global Positioning System (GPS) receiver
5.3.3 Field compass with inclinometer
5.3.4 Well tagging equipment
5.3.5 Clip board, piezometer installation form(s), and pencils
5.3.6 Digital camera
5.3.7 Small step ladder (as necessary)
5.3.8 Floating work platform and inner tube (as necessary)
5.3.9 Calibrated low-displacement e-tape (as necessary)
5.3.10 Stilling tube (as necessary)
5.3.11 Fence post driver, sledge hammer, PVC drive rod, gas jackhammer, drop hammer and tripod assembly (as appropriate)
5.3.12 Manual bilge pump with fittings and a 10 to 12-foot length of ½ -inch diameter polyethylene tubing (to develop rigid piezometers)

5.3.13 Peristaltic pump, charged portable 12-volt battery, and silastic tubing (as necessary)
5.3.14 Plugs or caps (tubing piezometers)
5.3.15 Pipe weights (tubing piezometers)

5.4 Water Level Monitoring and Thermistor Deployment

5.4.1 Peristaltic pump, charged portable 12-volt battery, and silastic tubing (as appropriate)
5.4.2 Manometer board and tubing (as appropriate)
5.4.3 Calibrated low displacement e-tape (as appropriate)
5.4.4 Stilling tube
5.4.5 Pre-calibrated and launched thermistors (four thermistors per piezometer for initial deployment)
5.4.6 Extra piezometer cap(s), coupler(s), and extension pipe(s) (as appropriate)
5.4.7 Pre-launched thermistor shuttle(s) (to download thermistors)
5.4.8 Extra pre-launched thermistors (replacements for failed thermistors)
5.4.9 Thermistor shade devices (see Bilhimer and Stohr, 2007)

5.5 Decommissioning Piezometers

5.5.1 Two high-lift jacks with extension handles and attached chains
5.5.2 Star clamp, appropriately sized for pipe (as necessary)
5.5.3 Five feet of heavy gage chain with end hook
5.5.4 16-pound sledge hammer (as necessary)
5.5.5 2-pound hand sledge
5.5.6 2-14 inch lengths of 2 inch by 8 inch board or heavy plywood (as necessary to support jack base)

6.0 Summary of Procedures

6.1 Project Planning

6.1.1.1 Successful deployment of in-water piezometers involves considerable up-front planning.

6.1.1.2 Previous studies and data must be assembled and evaluated (where available) to develop a preliminary conceptual model of SW/GW interactions for the study area.

6.1.1.3 Potential piezometer sites must be field scouted and selected.

6.1.1.4 Regulatory permits, variances, and waivers must be obtained from County and State agencies to install piezometers and perform in-water work.

6.1.1.5 Appropriate piezometer material(s) must be selected and piezometers designed and fabricated.

6.1.1 A brief discussion of these topics is presented below, as a primer for readers new to SW/GW interaction studies. New readers and others seeking a refresher should consult the excellent reference publications by Winter and others (1998), Stonestrom and Constantz (2003), and Rosenberry and LaBaugh (2008), prior to preparing project plans or installing piezometers. These documents present numerous SW/GW interaction case studies and contain a wealth of information about potential piezometer designs and deployment strategies.

6.2 *Preliminary Site Selection and Field Reconnaissance*

6.2.1 Before heading to the field, review previous seepage evaluations and other published information about the hydrogeologic setting and groundwater flow patterns for the study area. Note the location of geologic contacts, mapped springs, or other geomorphic features that might suggest where groundwater potentially discharges to the stream or water body of interest (see Konrad, 2006, and Rosenberry and LaBaugh, 2008 for additional guidance).

6.2.2 Use surficial geology maps and aerial photographs to tentatively identify locations where surficial bedrock exposures may prevent piezometer installation. From this assembled information, target stream reaches or shoreline areas to visit during site reconnaissance efforts.

6.2.3 The goal when selecting potential piezometer sites is to characterize the quality and quantity of groundwater that discharges to the water body of interest (such as areas of known contamination) while also providing estimates of the overall range in groundwater chemical concentrations and flux volumes/rates.

6.2.4 When selecting potential piezometer locations in the field target calm-water sites within wading distance of shore that can be safely accessed during all but flood periods and which will not be left dry when flows drop during baseflow periods.

6.2.5 Avoid locations near point bars, riffles, or steep drops that might locally induce surface-water flow through the streambed (hyporheic exchanges).

6.2.6 To minimize potential equipment vandalism, target locations where overhanging trees or bushes provide natural cover. Also, try to locate piezometers where they are least likely to be impacted by floating debris or boats.

6.2.7 Depending on the study objectives and local site conditions it may be necessary to install more than one piezometer per location to adequately characterize the subtleties of local SW/GW interactions.

6.2.8 Record the information collected during preliminary site visits on a piezometer reconnaissance field form or equivalent (see example in Appendix A). This information will be required when applying for well construction variances and site access permits.

6.3 *Regulatory Permits, Variances, and Waivers*

6.3.1 The project hydrogeologist is typically responsible for securing the regulatory permits and waivers to install in-water piezometers. These currently include a hydraulic project approval (HPA), a shorelines permit exemption, a DNR aquatic lands right of entry agreement (when working in navigable waters), and information about the location of nearby underground utilities. These approvals must be obtained *before* piezometer installation begins.

6.3.2 In-water piezometers are also subject to Washington's minimum well construction and licensure requirements (Chapter 18.104 RCW, Chapter 173-160WAC, and Chapter 173-162WAC). Accordingly, a licensed well driller (or engineer) must be present to oversee piezometer installation and removal. They are also responsible for signing and filing the well completion and abandonment reports for the project.

6.3.3 The steps required to secure environmental permits, variances, and regulatory waivers for in-water piezometers are outlined in Appendix B (also see footnote below) [1].

6.4 *Piezometer Material and Design Considerations*

6.4.1 In-water piezometers can be constructed from a variety of commonly available materials including steel (black, galvanized, or stainless), thick-walled PVC, or polyethylene tubing, among others (Table 1).

Table 1 – Suitability of piezometer materials for different applications

Material Type	Material and fabrication costs	Security	Design flexibility	Streambed hydraulic tests	Periodic water level monitoring	Continuous temperature or water level monitoring	Water quality monitoring
Flexible polyethylene tubing	$$	P-G	G-E	P	E	P	E
Rigid PVC pipe	$	P-G	G-E	G	E	E	E
Galvanized or black steel pipe	$$$	G-E	G-E	E	E	E	G-E

P-poor, G-good, E-excellent

6.4.2 When selecting piezometer material(s) and design(s) chose those that best complement the study goals and objectives. In some situations a variety of materials or designs may be the best approach.

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[1] NOTE: in 2008 EAP negotiated "state wide" HPA and DNR aquatic lands access agreements for the 2008-9 field season. The information in Appendix B is provided as a general guide, in the event these permits are not renewed during subsequent field seasons. In either case, the project manager is responsible for ensuring that the regulatory permits and wavers described in Appendix B are in place for their project **before** beginning field work.

6.4.3 Selecting an appropriate open-interval type (e.g. perforated pipe, filter fabric wrapped tubing, commercial stainless steel well point, etc.) is also an important design consideration. Again, select the open-interval type that best meets the study needs, budget, and site conditions.

6.5 *Steel Pipe Piezometers*

6.5.1 Piezometers constructed from galvanized or black steel pipe are relatively expensive but are robust and often reusable. They are well suited for longer-term deployments where equipment vandalism or frequent contact with floating debris is likely.

6.5.2 Steel offers significant flexibility during the initial design and subsequent maintenance of piezometers, due to the wide variety of fittings, couplers, and end-caps that are available at most hardware stores.

6.5.3 One-inch diameter or smaller steel piezometers are relatively easy to install and are well suited for manual water level and water quality monitoring.

6.5.4 Larger 1.5- inch piezometers are more difficult to install but have the added benefit of accommodating recording thermistors or pressure transducers. They can also be fabricated with a larger effective open interval and are therefore better suited for sediment hydraulic tests than smaller diameter steel or tubing piezometers.

6.5.5 If vandalism or encounters with floating debris are likely, steel piezometers can be fabricated with removable extensions that enable them to be capped and completed below the water surface between field visits.

6.5.6 Steel piezometers can also be combined with a flexible polyethylene tube that extends along the sediment surface to a safe access point on the shoreline. This arrangement enables piezometers to be safely measured or sampled during high-water periods.

6.6 *Flexible Polyethylene Tubing Piezometers*

6.6.1 Smaller-diameter tubing piezometers (e.g. 0.25 - inch ID polyethylene tubing) are relatively inexpensive to construct and may be easier to install than larger-diameter steel piezometers.

6.6.2 They are particularly well suited for lake deployments since they are easily hidden from boaters and swimmers.

6.6.3 Where floating debris is present or vandalism likely, tubing piezometers can be coiled and weighted to lie on the streambed or lake bottom between site visits.

6.6.4 Tubing piezometers may also the best choice when low-concentration sampling of metals is planned. They can also be fabricated with a fine mesh screen to help minimize the entry of fine sediment into the well.

6.6.5 Due to their small diameter however, tubing piezometers can’t accommodate recording thermistors or water level probes (e-tapes) and are not well suited for hydraulic tests.

6.7 *PVC and Stainless Steel Piezometers*

6.7.1 Piezometers can also be constructed using heavy walled PVC or stainless steel casing. Traditional steel piezometers can also be designed to accept pre-fabricated stainless steel well points. EAP has used these materials and designs only sparingly, however, due to cost (stainless) or difficulty of installation (PVC).

6.8 Piezometer Deployment

6.9 *Establishing a Permanent Reference Point on the Piezometer Casing*

6.9.1 The first step, when installing a piezometer, is to establish and document a *Permanent Reference Point (PRP)* on the piezometer casing (Figure 1). The PRP is used to track a piezometer’s geometry (installed depth, open interval, etc.) with respect to the sediment surface. This is important since the *effective* piezometer depth, open interval position, and installed instrumentation depths can change as surface sediments shift around the casing over time. These changes must be tracked to properly interpret SW/GW head relationships, bed-sediment thermal profiles, and other variables.

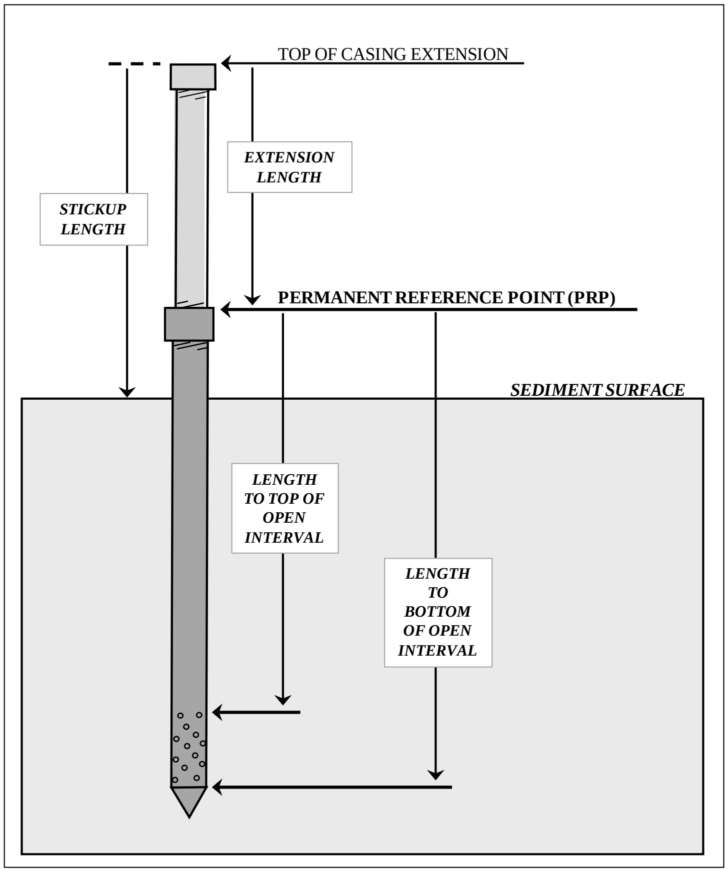

Figure 1– Schematic of a typical in-water piezometer

6.9.2 **Steel (or PVC) piezometers**: For steel, PVC, or other rigid piezometers select a PRP that will project above the sediment after the piezometer is driven to final depth. For single piece piezometers the PRP is usually defined as the top of casing with a pipe coupler attached. For multi-section piezometers the PRP is usually defined as the top of the pipe coupler attached to the lower-most 5-foot long perforated-casing segment. After establishing the PRP, lay the pipe assembly on a flat surface and use an engineer's hand tape to carefully measure:

6.9.2.1 The distance from the PRP to the top and bottom of the open interval. Be sure to include the *entire length* of pipe where water can enter the casing.

6.9.2.2 Also measure the extension length (if any) and the total inside casing length. Measure all lengths to the nearest 0.01 foot.

6.9.2.3 Record the above measurements and other pertinent information (such as the pipe type, diameter, and the screen or perforation type) on a piezometer installation field form or equivalent (see example form in appendix A).

6.9.3 **Flexible tubing piezometers**: the PRP for flexible tubing piezometers is generally defined as the upper end of the tubing opposite the drive point.

6.9.3.1 When installing a standard 5-foot deep tubing piezometer start with at least 10 feet of tubing.

6.9.3.2 Lay the tubing section on a flat surface and carefully measure its overall length (including the drive point) with an engineer's hand tape.

6.9.3.3 Measure the distance from the PRP to the top and bottom of the open interval. Record all values on the piezometer installation field form. (Note: The initial depth of a tubing piezometer is determined after installation by subtracting the tubing length that projects above the sediment surface, after installation, from the total beginning length measured above.)

6.10 *Piezometer Installation*

6.10.1 Piezometers can be installed with a fence post driver, a tripod and drop-hammer, a gas-powered jack-hammer, or similar means (Figure 2). Choose the most appropriate installation method based on local site and permit conditions.

Tripod and drop hammer

Fence post driver


Gas powered jack hammer

Figure 2 – Common Tools for Piezometer Installation

6.10.2 **Steel piezometers**: Before driving the casing attach a temporary drive cap or coupler to the casing top to protect the pipe threads. Use a pair of pipe wrenches to confirm that all couplers and caps are tight and secure. (Note: Teflon plumbers tape should be used to seal any joints that might potentially leak due to worn or loose threads. Do not use plumbers putty or other sealants that might potentially bias future water-quality results).

6.10.2.1 Begin driving the piezometer - keeping the casing as vertical as possible. If the casing strays significantly from vertical, while still at a shallow depth, remove it and try driving again a few feet away. Strive for a vertical installation where possible.

6.10.2.2 If near-surface bedrock or consolidated sediments prevent piezometer installation note the location on the field form and move to a nearby site. Try to avoid too much casing "bounce" while driving as this can damage pipe threads or loosen couplings.

6.10.2.3 Periodically stop and retighten any loose couplers or caps as the casing is advanced.

6.10.2.4 If conditions allow, drive the casing until the PRP lies about 6 inches above the sediment surface. This will enable the piezometer to be capped below the water surface, if desired (assuming the PRP was established at the top of the casing coupler attached to the lowermost casing segment as described above).

6.10.2.5 Below-water completions are less prone to vandalism or impacts from floating debris. However, an extension is required to raise the piezometer above the water surface during field visits. (Note: when sampling for water quality an extension can be left in place, between visits, to prevent surface water from entering the casing when the cap is removed).

6.10.3 **Flexible Tubing Piezometers**: Tubing piezometers are installed using a rigid-temporary-drive pipe that must be removed after the tubing is driven to final depth. Extracting the drive pipe can leave an annular space that must be collapsed around the tubing to isolate the piezometer from the overlying surface water. To minimize the potential for water leakage along the casing, use a drive pipe/drive point only slightly larger in diameter than the piezometer tubing. Also, pack fine surface sediments tightly around the tubing as (and after) the drive pipe is removed. (Note: If a tubing piezometer is installed at an angle, measure and record the angle if the drive pipe (as degrees from vertical) before extracting it so that geometric corrections can be made to define the installation depth of the piezometer and open interval).

6.10.4 Observations to Note and Record – All Sites

6.10.4.1 As the piezometer casing (or temporary drive pipe) is driven make note of the general nature of the surficial sediments that are encountered; such as the general clast size and degree of sorting. Also note the relative effort required to advance the casing or drive pipe with depth.

6.10.4.2 The goal is to develop a qualitative sense of the type(s) and relative compactness of the sediments encountered at each piezometer site. This information will be used to prepare the piezometer well report. It also provides a context for evaluating subsequent hydraulic tests or water quality sampling that may be undertaken.

6.11 Piezometer Development and Completion

6.12 Piezometer installation disturbs the sediments in the immediate vicinity of the drive pipe or casing. Consequently, all piezometers must be developed after installation to remove sediment that accumulates in the casing or open interval; thereby ensuring the piezometer has an unobstructed hydraulic connection with the surrounding sediments. (Note: If a piezometer will be used to test or evaluate sediment hydraulic properties (such as CHIT tests) perform these tests *before* proceeding with *rigorous* well development (see Cardenas and Zlotnik, 2003; Pitz, 2006).

6.13 **Steel (or PVC) piezometers:** Steel (or PVC) piezometers of one-inch or larger diameter are developed using a manual-bladder-type bilge pump and a 10-12 foot length of ½ inch diameter polyethylene tubing (Figure 3).

Figure 3 – Bilge pump development of a steel piezometer

6.13.1 Begin development for these larger diameter piezometers by attaching one end of the polyethylene tube to the inlet (suction) port of the bilge pump (Note: the direction of water flow is indicated on the pump ports).

6.13.2 Insert the second end of the tubing into the piezometer until it rests on the piezometer bottom.

6.13.3 Pump any accumulated sediments from the casing. (Note: The pump body may need to be submerged in the surface water during the first few strokes to prime it with water).

6.13.4 Transfer the tubing to the pump outlet (pressure) port and slowly raise and lower the tubing across the length of the piezometer open interval while pumping water from the stream (or lake) into the casing.

6.13.5 Reset the tubing to the pump inlet port and again remove accumulated sediments from the casing.

6.13.6 Repeat this cycle until the piezometer produces a sustained supply of sediment free water. (Note: Sediments with significant silt or clay content may require more vigorous development to loosen and remove “smeared” fines from the well screen or perforations. In such cases it may help to simulate a “surge-block” effect by vigorously raising and lowering the tubing a few feet while alternatively pumping water into then out of the casing).

6.13.7 Smaller diameter (< one inch) steel or PVC piezometers are developed in similar fashion using a peristaltic pump and an 8-10 foot length of rigid ¼ inch diameter polyethylene tubing.

6.13.8 When development appears complete, confirm that the piezometer freely exchanges water with the surrounding sediments (subject to sediment limitations). Do this by filling the casing with surface water and watching for a short time to confirm that the level moves toward its natural equilibrium position.

6.13.9 Check that the piezometer is hydraulically isolated from the overlying surface water by visually comparing (or measuring) the hydraulic heads (water levels) inside and outside of the piezometer casing. A distinct head difference suggests that the piezometer has an effective casing (annular) seal.

6.13.10 As a secondary check, purge the piezometer with a peristaltic pump and periodically measure the waters dissolved oxygen (DO) and specific conductance (SC) concentrations. Purge until equilibrium is achieved. Compare the piezometer values to those for surface water. Groundwater often has lower DO concentrations and higher SC values than surface water.

6.13.11 If the water level and water quality values of the surface water and piezometer are the same, it's possible that surface water is entering the piezometer via a poorly sealed casing annulus. In such cases repack sediments around the casing and repeat the above tests. (Note: If these initial attempts do not adequately seal the casing, try deepening the piezometer (if practical) or allowing surface sediments to naturally repack around the casing for a few weeks before repeating the above tests. (Note: Additional leakage evaluations, such as dye testing, may be necessary to confirm the adequacy of the casing annular seal).

6.13.12 Complete the installation by measuring the maximum casing incline (as degrees away from vertical). Record the result in the installation field form.

6.13.13 Attach an Ecology well tag to the casing using heavy gage aluminum wire. Record the tag number and piezometer description on the installation field form.

6.13.14 Collect and record final GPS coordinates for the piezometer per EAP SOP-013 (Janisch, 2006).

6.13.15 Describe and/or sketch the piezometer location including its position (left bank/right bank) and distance/bearing from local landmarks.

6.13.16 Take a few wide-angle photographs of the piezometer showing its location relative to the described landmarks. Note the photo sequence number on the installation form.

6.13.17 Determine the casing stickup by extending a steel hand tape *along* the length of the casing and measuring the distance from the sediment surface to the top of the piezometer casing – including the length of any attached extension(s). Record the value on the installation form to the nearest 0.01 foot. (Note: If the piezometer is not vertical remember to measure the stickup (and associated water levels) from the lowest point along the casing rim).

6.13.18 Next measure the attached length of any extensions or couplers that were added to the piezometer upon arrival. Record the value on the field form.

6.13.19 Finally, measure and record the initial hydraulic head values for the piezometer and surrounding surface water (see section 6.17 - routine monitoring - for details).

6.14 **Tubing Piezometers:** Tubing piezometers (like smaller diameter rigid piezometers) are best developed using a peristaltic pump.

6.14.1 Begin development by connecting the silastic tubing from the pump directly to the upper end of the piezometer tubing. Start the pump and alternately pump water into and out of the piezometer by periodically reversing the pump direction.

6.14.2 Repeat this process until the piezometer produces a sustained discharge of sediment free water (subject to formation limitations). A floating platform can be used to hold the pump and battery if necessary.

6.14.3 When development is complete perform the casing-seal evaluation outlined in sections 6.13.8 through 6.13.10.

6.14.4 Measure and record the length of tubing that projects above the sediment surface (to the nearest 0.01 foot).

6.14.5 Subtract this length from the *total initial* tubing length (see Section 6.9.3.2) to determine the installation depth. Note these values on the piezometer installation form. The previously measured drive casing angle (if any) can be used to correct this value to a vertical depth.

6.14.6 Establish a permanent water level measuring point (MP) at a convenient point on the tubing. Select a point that will always be above the water surface when the tubing is held vertically – regardless of river stage. Permanently mark the water level MP with an indelible ink pen or a plastic zip tie secured firmly around the piezometer tubing.

6.14.7 Hold the tubing vertical and use a steel hand tape to measure the distance between the water level MP and the sediment surface, to the nearest 0.01 foot. Record this value as the initial piezometer stickup length on the piezometer installation form. This initial stickup value will be used to track changes in effective piezometer depth due to sediment deposition or scour.

6.14.8 While holding the tubing vertical measure and record the initial hydraulic head values for the piezometer and surrounding surface water (see Section 6.17 for details).

6.14.9 Submerge the exposed end of the tubing to remove all air then plug or cap the end with a rubber stopper or equivalent to keep sediment or debris from entering the piezometer.

6.14.10 Arrange the tubing into a loose coil (leaving enough free tubing to allow it to be lifted above the water surface during the next field visit) and attach a pipe or other suitable weight to the coil with plastic zip ties.

6.14.11 Attach an Ecology well tag around the weight with a zip tie or heavy gage wire. Record the tag number and piezometer description in the field notes.

6.14.12 Lay the tubing assembly on the sediment surface and cover it with sediment or rocks (as necessary) to hold it in place.

6.14.13 Collect and record final GPS coordinates for the piezometer per EAP SOP-013 (Janisch, 2006).

6.14.14 Describe and/or sketch the piezometer location on the field form including its position (left bank/right bank) and distance/bearing from local landmarks. To supplement the field notes take a few wide-angle photographs of the piezometer showing its location relative to described landmarks.

6.15 General Development Considerations - All Piezometers

6.15.1 Regardless of piezometer type, track pertinent information about the development process on the installation form. For example, does the piezometer develop quickly with only minimal silt and sand production or does it develop slowly producing considerable silt and sand that clears only after a period of extended development? Does the piezometer easily take and produce water or does it exchange little water even after extended development? Except in the finest of sediments the piezometer water level should perceptibly raise or fall as it moves toward its natural equilibrium condition. This information will prove useful when preparing the formal well report and will provide a qualitative check of the results from any hydraulic tests that are run.

6.15.2 Occasionally piezometers are completed with their screen or perforations above the water table (e.g. along a ‘losing’ stream reach). In such cases the piezometer may quickly pump dry and appear to be clogged or undeveloped. In these situations confirm development by verifying that the piezometer ‘takes’ water introduced into the casing. If the piezometer won’t accept water the open interval may be clogged and need further development. Alternatively, the sediments may simply be too fine to transmit much water. If continued development doesn’t improve well yield, and/or the water that is produced remains highly turbid, it’s likely the piezometer is installed in low permeability sediments. With experience, you will gain a feel for the relative grain size and compactness of the sediments encountered while installing a piezometer.

6.16 Thermistor Installation

6.16.1 Rigid pipe piezometers are often instrumented with recording thermistors to help estimate the thermal load (or buffering potential) that discharging groundwater imparts to surface water. Instrumenting a standard 1.5 inch diameter steel or PVC piezometer requires four pre-calibrated and launched thermistors and one roll each of 12-14 gage and 20-22 gage aluminum or galvanized wire.

6.16.2 To prepare the thermistor hanger begin by cutting a piece of the heavy-gage wire from the roll that is approximately 2-3 feet longer than the total depth (length) of the piezometer being instrumented.

6.16.3 Form a small closed loop at one end of the wire with a pair of needle nose pliers. This loop serves as the base (or foot) that the thermistor hanger wire sits on when it is installed in the piezometer[2].

6.16.4 Form a small crimp about 8 inches above the hanger foot to anchor the lower-most thermistor (Figure 4).

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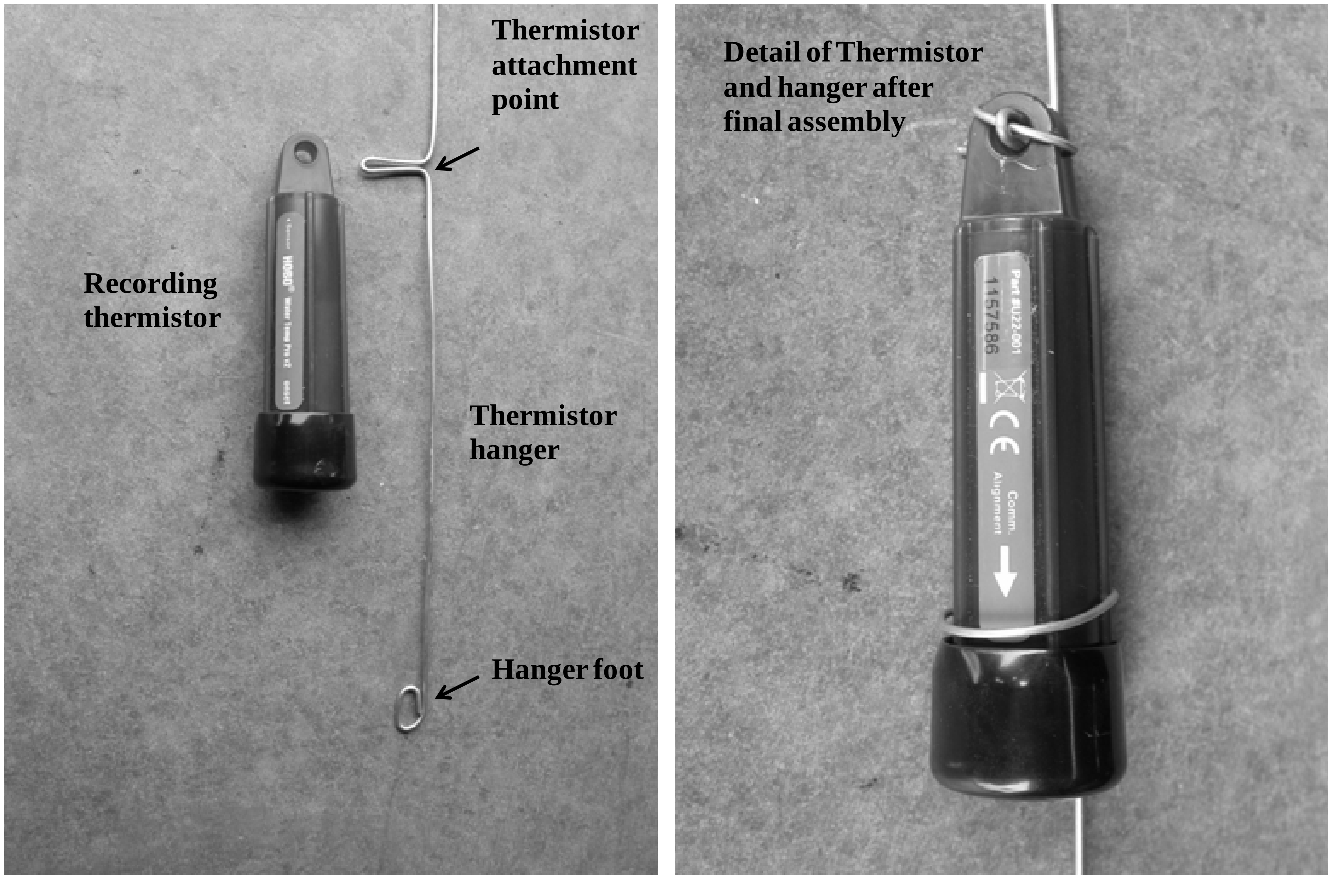
[2] EAP typically installs thermistors using a heavy gage support wire that rests on the piezometer bottom. However, thermistors can also be weighted and suspended on small diameter cable from an anchor point on the piezometer cap or upper casing. Suspended thermistor deployments are generally used when a combination of thermistors and transducers are deployed in a single piezometer.



(Before) (After)

Figure 4 - Details of a typical thermistor and hanger array shown before and after final assembly

6.16.5 For piezometers installed along a *losing* reach form a second crimp about 0.75-1.0 foot below the sediment surface to anchor the uppermost thermistor.

6.16.6 Add a third crimp approximately mid-way between the upper and lower thermistor anchors to attach the middle thermistor. (Note: For piezometers extending less than 2 feet into the sediments the middle thermistor is often omitted).

6.16.7 For piezometers installed along a *gaining* reach the upper thermistor should be placed higher on the hanger (about 0.5 – 0.6 feet below the sediment surface) so that it records the muted diurnal temperature signal the surface water imparts on the upwelling groundwater (see Stonestrom and Constantz, 2003). Similarly, the middle thermistor should be placed somewhat above the midpoint location between the upper and lower thermistors to ensure that the middle thermistor records temperatures that are distinguishable from those of the lower thermistor.

6.16.8 To determine where best to place the middle thermistor along the hanger, check sediment thermal conditions by lowering a long line thermistor to the bottom of the piezometer. Wait for the temperature to stabilize and record the value and depth on the piezometer installation form. Then slowly raise the thermistor by approximately 0.5 foot increments while recording the corresponding (stable) temperature for each interval. Use this initial thermal profile to help place the middle thermistor approximately midway between the temperature extremes recorded at the piezometer top and bottom.

6.16.9 When the hanger is complete, attach a thermistor to the lowermost anchor point and secure it in place at the top and bottom with light gage wire or small zip-ties (Figure 4). Make the lower wire (or zip tie) snug enough to hold the thermistor securely against the hanger but not so tight that the thermistor cap can't be removed during downloads.

6.16.10 Install the middle and upper thermistors in similar fashion.

6.16.11 Write the thermistor IDs and their positions (upper, middle, lower) on the field form.

6.16.12 Slip the lower end of the thermistor string into the piezometer and press it down until the hanger foot rests firmly on the casing bottom (Figure 5).

6.16.13 Gently rotate the hanger to confirm that it's seated at the lowest point in the casing.

Figure 5 - Deploying a thermistor array into an in-water piezometer

6.16.14 Now bend the remaining wire over the casing top so that the resulting bend marks the position of the piezometer reference point (PRP) established prior to installation. (Note: When using heavy-gage wire it may be easier to mark the position of the casing top on the hanger wire with a piece of tape or an indelible ink pen – rather than bending the wire over the casing top).

6.16.15 Remove the hanger. With a steel engineers tape measure the distance from the top of the bend (or mark) to the sensor position near the upper end of each thermistor. Measure distances to the nearest 0.01foot and record them on the installation form. These values represent the initial thermistor depths relative to the PRP.

6.16.16 Measure the distance from the piezometer PRP to the sediment surface. Subtract this value from each of the thermistor depths just measured (section 6.16.15) to define the initial thermistor depths in feet below the sediment surface.

6.16.17 Reinstall the thermistor hanger, keeping the extra wire folded over so that it can be inserted into the piezometer and serve as a retrieval handle during subsequent measurements. (Note: Do not remove the extra wire – particularly if an extension may be added to the piezometer at some later point to enable it to be sampled. The extra wire will enable the thermistors to be retrieved without having to remove the extension).

6.16.18 Attach a 2 foot length of heavy gage wire to the remaining thermistor. Note the thermistor ID on the piezometer installation form.

6.16.19 Thread the wire through one of the holes on a standard PCV shade device and pull the wire tight until the thermistor is seated snug inside the PVC.

6.16.20 Securely attach the surface water thermistor to the outside of the piezometer casing by wrapping the remaining wire around the casing a few times and then several times around the wire itself.

6.16.21 Position the thermistor so that it lies about midway between the water surface and the bed sediments. (Note: If you expect the surface water stage (level) to drop significantly before the next field visit, position the thermistor lower in the water column to prevent it from being exposed to the air. However, do not rest the thermistor directly on the sediment surface).

6.16.22 Measure the distances from the thermistor to the water surface and from the thermistor to the bed sediments. Record the values on the installation form.

6.16.23 After thermistor installation is complete securely cap the upper end of the piezometer to prevent debris or surface water from entering the casing. (Note: Low yield piezometers or those that are instrumented with transducers, should be completed with an above-water extension and vented cap (or equivalent) so that the water level accurately reflects true static conditions when the cap is in place).

6.16.24 Piezometers that are routinely sampled for water quality can also be completed (extended) above the water surface during the sampling period to prevent surface water from entering the well when the cap is removed. The extension(s) can be removed during non-sampling periods to protect the piezometer from impact damage or vandalism.

6.17 Routine Monitoring of Piezometers

6.17.1 A principal use of in-water piezometers is to monitor the water level (head) relationships between a surface water body and the near-surface groundwater at discrete points (Figure 6). Piezometer networks installed along the length of a stream (or lake) can be used to quickly and easily track where gains from or loses to groundwater occur over time. Such measurements are useful for confirming the reach-based water exchanges estimated from stream seepage evaluations.

6.17.2 To normalize for differences in piezometer depth between sites, field-measured water levels are typically converted to vertical hydraulic gradients using the relation:

6.17.2.1 $i_v = dh/dl$ (Equation 1)

6.17.2.2 **where:** **i_v = the vertical hydraulic gradient (dimensionless)**

6.17.2.3 ***dh* = the vertical distance from the piezometer water level measuring point to the surface water stage *minus* the vertical distance from the water level measuring point to the piezometer water level (see Figure 6)** [3]

6.17.2.4 ***dl* = the vertical distance from the sediment surface to the midpoint of the piezometer's screened or perforated interval**

6.17.3 Negative values of $\mathbf{i_v}$ indicate the potential for downward movement of water from surface water to groundwater (loss), while positive values indicate upward movement of groundwater into the surface water body (gain).

6.17.4 Hydraulic gradient measurements can be made by periodic manual means such as a low displacement E-tape, chalked steel tape, or manometer board; or they can be measured and recorded more frequently using an automated pressure transducer. (Note: transducer calibration, installation, and use is covered under a separate SOP).

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[3] By convention, if the stream stage is higher in elevation than the piezometer water level, the ***dh*** value is a *negative* number. If the piezometer water level is higher than the stream stage, the ***dh*** value is *positive*. Note that Equation 1 provides an estimate of vertical hydraulic gradient *averaged* over the length of the piezometer screen or perforations.

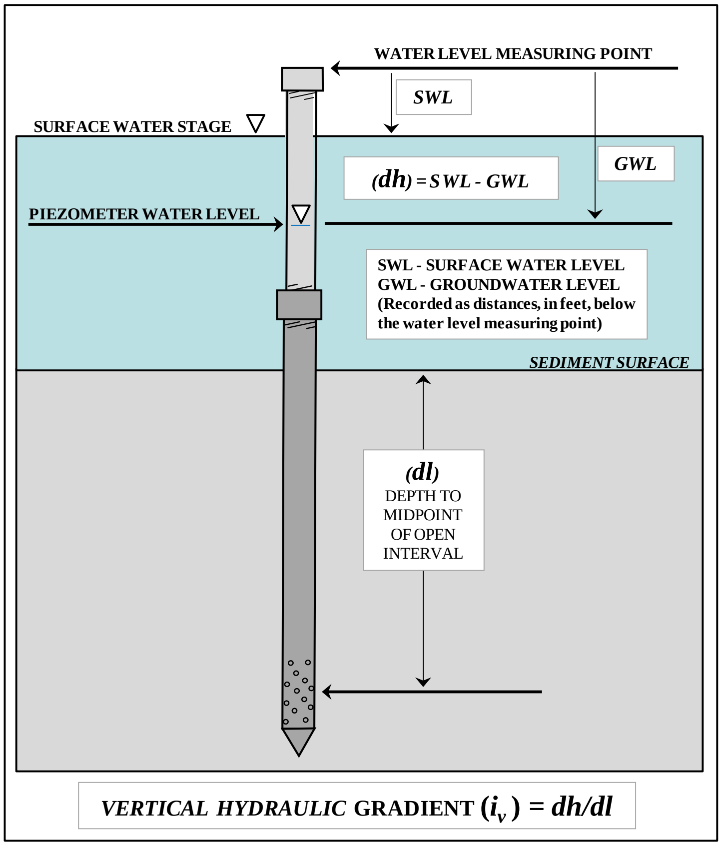

Figure 6 – Determination of Surface water and groundwater head relationships using an in-water piezometer

6.17.5 Measuring Hydraulic Heads and Sediment Temperatures in Pipe Piezometers

6.17.5.1 After arriving at the piezometer fill out the header fields on the field form including - the well tag ID, site location, crew members, weather conditions, date and time. (See example Water Level Measurement Form, Appendix A).

6.17.5.2 Use two pipe wrenches to remove the piezometer cap. (Note: Always use two wrenches when installing or removing caps or extensions to prevent the piezometer from rotating and potentially compromising the casing seal).

6.17.5.3 Attach an extension pipe (if necessary) to extend the casing rim above the water surface.

6.17.5.4 If the piezometer recovers slowly and contains thermistors or other instrumentation, attempt to measure the water level before removing the instruments.

6.17.5.5 If instrument removal is required, note the ‘reference’ position of the instrument hanger so it can be returned to the same position when your work is complete. Record the thermistor removal time on the field form so that temperatures or water levels that are logged while the instruments are out of the piezometer can be identified and removed from the data record (see Bilhimer and Stohr, 2007 for additional guidance).

6.17.5.6 Collect and record the following measurements as positive values, to the nearest 0.01 ft, using the piezometer casing top (with extension attached if appropriate) as the water level reference point[4].

6.17.5.6.1 The distance from the casing top to the surface water level (the *"S Length" on* Figure 7). Measure *along* the casing with an engineer's hand-tape. For inclined piezometers the surface water level (and subsequent piezometer measurements) should be measured from the *lowermost* point of the casing circumference (see Figure 7). In fast flowing water a clear or translucent stilling tube may be used to stabilize the surface water stage during measurement.

6.17.5.6.2 If the surface water level drops to the point that the piezometer is no longer contained within the active (wetted) area of the stream or lake, note this on the data form. A manometer board must be used to measure the piezometer in such cases (see the manometer measurement section).

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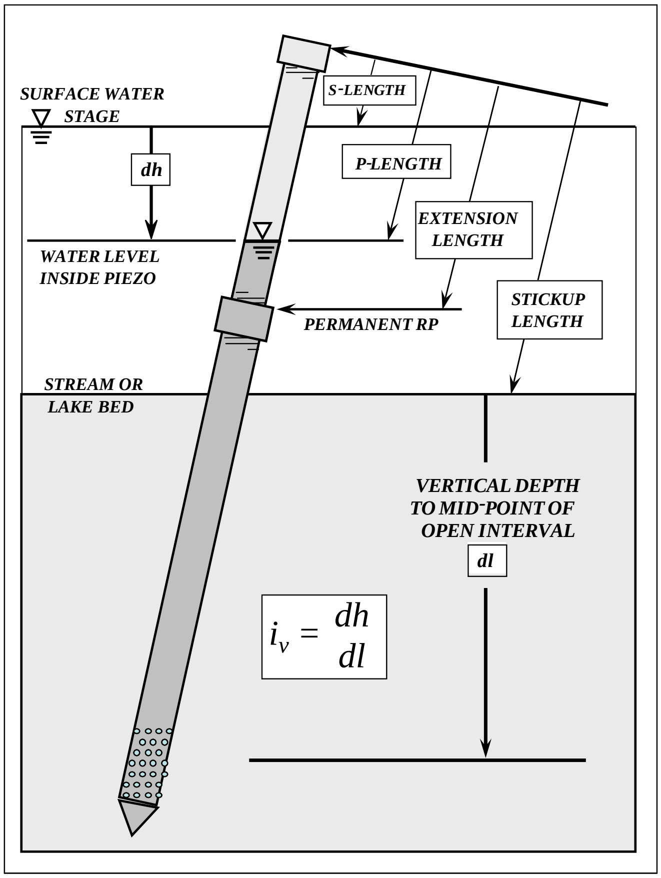
[4] For vertical (non-inclined) casings the convention is to measure water levels from the north-side of the casing rim. Whatever measuring point (MP) scheme you choose, apply it consistently to all piezometers in the study and describe the location for each piezometer in your field notes. All subsequent stickup, water levels, and other measurements should be made from this same location. For inclined (off-vertical) piezometers, the water level MP should be located at the lowest point of the arc defined by the top rim of the piezometer casing (Figure 7).

Piezometer Water Level Field Sheet (Hand)

Date: ___________ **Time:** ___________ **Crew:** _________________

Tag ID: _______________ **Piezo Name:** ______________________



Water Level MP: TOC other: ______________________________

E-tape #:	Hold	Cut
S-Length	ft	ft
P-Length	ft	ft
Extension Length	ft	ft
Stickup Length	ft	ft
Total Interior Length	ft	ft

Measure inclined lengths, not corrected vertical heights

Figure 7 – Example Field Form for Recording Piezometer Water Level Data

6.17.5.6.3 Measure the depth to groundwater *inside* the piezometer (the *"P length" on Figure 7*) from the same point, using a properly calibrated e-tape or chalked steel tape (Marti, 2009) (Figure 8). Record the tape 'cut' value (if any) and the ID of the e-tape on the field form. Measure the piezometer water level at least twice (preferably separated by a few minutes) to confirm the level represents static conditions. If the water levels inside and outside the piezometer casing are very close, hand measurement may not be sufficiently accurate to estimate the hydraulic gradient. In such cases, use a manometer board (see Section 6.17.7.0). (Note:

When large negative gradients are encountered always check the piezometer construction log and associated reference measurements to confirm that the groundwater level hasn't dropped below the piezometers perforated interval. If it has, the water level may not represent true static conditions - particularly if the perforations do not extend to the bottom of the piezometer).

6.17.5.6.4 Use an engineer's hand tape to measure the *effective* length of any extension(s) that were added to the piezometer. This is the distance from the top of the uppermost extension (if more than one is used) to the piezometer PRP. Record the value on the field form (Figure 7). (Note: The PRP is *usually* the top of the pipe coupler attached to the lowermost piezometer segment. Always consult the piezometer well completion report (well log) when the position of the PRP is in doubt).

6.17.5.6.5 Use an engineer's hand tape to measure the casing "*stick-up length*". This is the distance from the piezometer measuring point at the top of the casing (TOC) to the sediment surface as measured *along the casing*. Record the result on the field form.

Figure 8 - Using an E-tape to measure the water level in an inclined steel piezometer

6.17.5.6.6 Use an engineer's hand tape to measure the total interior length of the piezometer (including any attached extensions or couplers) and record the result on the field form. (Note: This information is used to determine if the piezometer is filling with sediment over time and therefore in need of re-development).

6.17.5.6.7 After completing the above measurements, proceed with thermistor downloads (see Bilhimer and Stohr, 2007 for details) or water quality sampling as appropriate[5]. When done, return any continuous data instrumentation to its correct position in the piezometer and note the reinstall time on the field form.

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[5] The order of these steps can be rearranged to accommodate the needs of individual piezometers. For example thermistors can be downloaded while waiting for the piezometer water level to stabilize after removing the cap or

6.17.5.6.8 Visually scan the field form to confirm that all measurements were completed and that the corresponding values were recorded in their appropriate location.

6.17.5.6.9 Remove any extensions that were added to the piezometer on arrival and re-cap the casing. (Note: Always use two pipe wrenches to prevent the casing from spinning and potentially compromising the annular seal).

6.17.6 Measuring Hydraulic Heads in Flexible Tubing Piezometers

6.17.6.1 After locating the piezometer bring the tubing coil to the surface. Record the date and time, well tag ID, piezometer name, and other site data on the field form.

6.17.6.2 Remove the upper end cap or plug from the tubing. While holding the open tubing end above the water surface, wait for the groundwater level to equilibrate with the atmosphere. In low permeability sediments it can take several minutes or more for the groundwater level to reach equilibrium. (Note: Check to make sure there aren't water pockets in the tubing above the water surface since they can block free-air exchange with the atmosphere. Flick or tap the tubing to dislodge any droplets).

6.17.6.3 Hold the tubing as vertical as possible and with an engineer's hand-tape measure the casing stickup to the nearest 0.01 foot. This is the distance from the sediment surface to the permanent measuring point (MP) established on the tubing during installation. Record the measured value on your field form.

6.17.6.4 When the piezometer water level is stable fill a stilling tube (the same diameter as the piezometer) with water, and hold it against the casing so that the stilling tube mid-point lies at approximately the same level as the surface water stage. Hold both tubes still and as vertical as possible once in position. Allow the water in the stilling tube to drain until it equilibrates with the surface water.

6.17.6.5 Use a metric scale to measure the difference (distance) between the water level inside the piezometer (groundwater head) and the water level in the stilling tube (surface water head) (Figure 9). Repeat the measurement a few times to confirm the piezometer is fully equilibrated. Record the final stable reading on the field form to the nearest centimeter and millimeter.

6.17.6.6 If the hydraulic head in the piezometer is below the surface water stage, a manometer board will be needed to measure the head difference (see Section 6.17.7.0).

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attaching an extension. The important thing is to confirm that the piezometer water levels have stabilized prior to final measurement and to remember to complete all the indicated steps - regardless of the order they are performed in.


Figure 9 – Using a metric scale and stilling tube to measure relative heads in a tubing piezometer

6.17.7.0 Using a Manometer Board to Measure Hydraulic Heads in Piezometers

6.17.7.1 In some situations a manometer board may be the only practical way to measure water level relationships (hydraulic head differences) between surface water and groundwater (Winter, et al, 1988). Manometer boards are particularly useful for measuring small head differences or when ripples or water surges make it difficult to accurately measure surface-water stage with a steel tape. A manometer board may also be required to measure tubing piezometers installed along losing reaches or where a piezometer no longer lies in direct contact with surface water.

6.17.7.2 (Note: Manometer boards should be tested and calibrated at the beginning of each field season (and periodically during use) to ensure they don't have air leaks and are otherwise working properly. The simplest way to perform this test is to position two "identical" 5-gallon buckets of clean water side-by-side on a level surface. One bucket should have more water than the other so that their water surfaces settle at different heights when stable. Set up the manometer board so that the lower "surface water" and "piezometer" tubes rest well below the water surface in their respective buckets. Charge the manometer board per the instructions below, turn off the pump, and disconnect the pump tubing from the upper manometer valve. Measure and record the distance from the top of each bucket to its corresponding water surface using a metric ruler. Proceed with the replicate manometer board measurements (5 sets) using the techniques described below, and then compare the average of these values to the initial water level difference measured for the buckets. If all is working correctly, the average head difference from the manometer should match the initial water level difference measured using the metric scale).

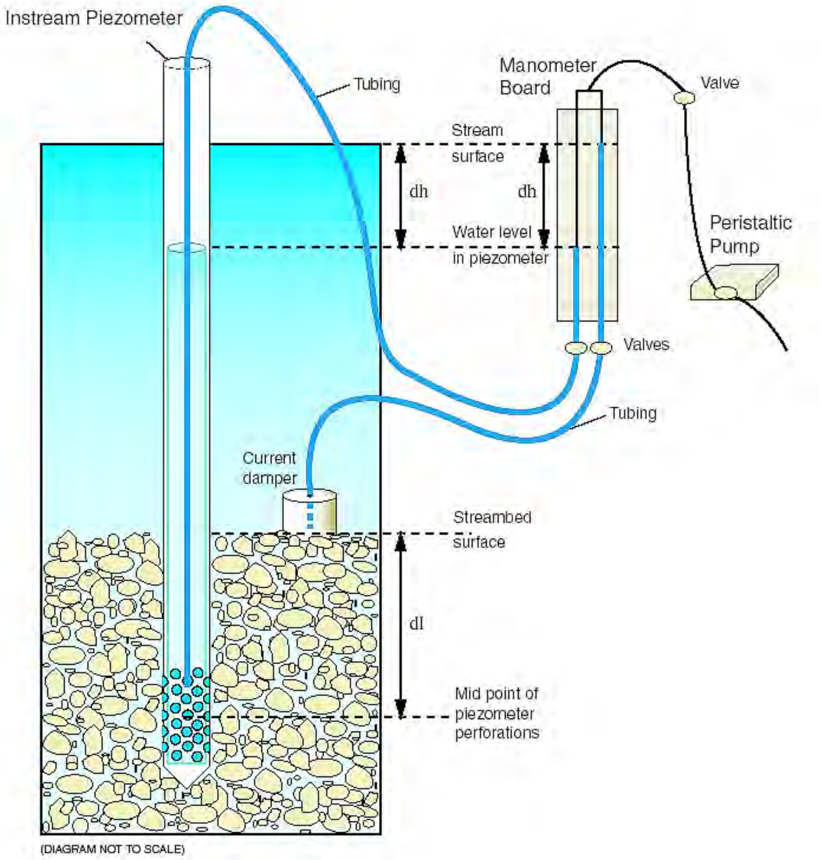

Figure 10 - Typical Manometer Board Setup (figure courtesy of F.W. Simonds, USGS, Tacoma, WA)

6.17.7.3 Manometer board use typically requires a battery, peristaltic pump, and a floating platform to hold the assembled equipment. Set up the floating platform, peristaltic pump, and battery adjacent to the piezometer casing and secure in place.

6.17.7.4 Attach one end of the silastic tubing from the peristaltic pump to the top barbed tubing-fitting on the manometer board (Figure 10).

6.17.7.5 For pipe piezometers place one of the lower manometer tubes (typically the right-hand tube) into the piezometer, so that it extends well below the piezometer water level. (Note: if the piezometer contains thermistors they will likely need to be removed before inserting the manometer tubing. If so, record the thermistor removal time on the field form).

6.17.7.6 For tubing piezometers secure the manometer tubing directly to the piezometer tube.

6.17.7.7 Insert the second manometer tube into a current damper and place the damper into the surface water so that the manometer tube remains under water but does not rest directly on the sediment surface (where it might clog with fine sediment).

6.17.7.8 Make sure all three manometer valves (one upper and two lower) are in their closed position.

6.17.7.9 Rest (or clamp) the manometer board on the piezometer casing or other stable surface. Open the top valve that leads to the pump and the lower valve that leads to the surface water tubing.

6.17.7.10 Start the pump and completely fill the surface-water side of the manometer with water from the stream or lake. The surface tubing should be *completely* full of water with no visible bubbles or sediment.

6.17.7.11 When the surface tubing is fully charged, slowly open the third valve and fill the remaining tube with water from the piezometer. As the piezometer tube fills, tap the board firmly with the flat of your hand to ensure both sides of the manometer are filled with water and to remove any air bubbles or sediment that may be trapped in the tube.

6.17.7.12 When both sides of the manometer are full with water, close the top valve that leads to the pump and shut the pump off. Disconnect the pump tubing from the top valve. (Note: leave the lower two valves open).

6.17.7.13 *Briefly* open the top valve and let just enough air into the manometer so that the water level drops to the point that you can see the location of the air/water interface for both tubes on the manometer scale.

6.17.7.14 Hold the manometer stable and as vertical as possible (use the levels on the board to confirm this) and allow the water levels to stabilize. Read the level at the bottom-most point of the meniscus in each tube and record the values to the nearest centimeter and millimeter in the appropriate columns (surface stage or groundwater level) of the field form (Appendix A).

6.17.7.15 After completing the first reading, *briefly* re-open the top valve and let additional air into the manometer. Again, allow the water levels in each tube to stabilize while holding the manometer steady/vertical. Record the resultant readings on the field form. Repeat this procedure until 5 or more readings have been obtained[6]. (Note: It may be necessary to give the manometer a good rap between measurements to release air bubbles or water droplets stuck to the manometer tubing).

6.17.7.16 If all is working well, the resultant readings should show approximately the same head difference and can be combined to define the average difference (dh) for that

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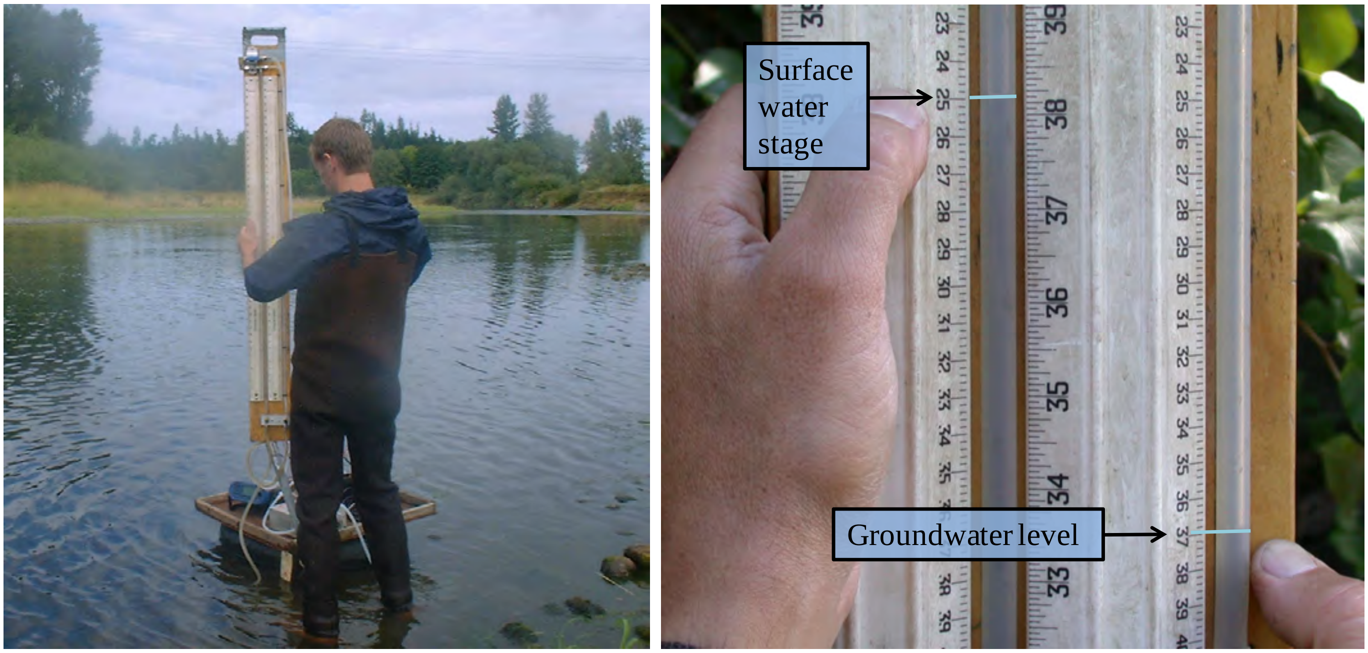
[6] When measuring piezometers with large gradients, it may not be possible to complete all 5 readings without first recharging the manometer with water.

site and measurement event. (Note: If the readings are inconsistent or gradually decrease in magnitude from reading to reading, check the manometer for vacuum leaks).

6.17.7.17 If there are no leaks, then it's likely the piezometer is completed in low-permeability sediments and is still recovering after being pumped to charge the manometer. Manometer boards are not well suited for such conditions since the act of charging the manometer may cause the piezometer to run dry or drawdown to non-static head conditions that do not recover to equilibrium conditions within a reasonable time period. A manometer board should not be used to measure heads in these situations.



(In use) (Detail of water levels)

Figure 11 - Manometer board in use and detail of manometer water levels

6.17.7.18 As a final check and memory jog for later data analysis, determine the direction of water movement indicated by the manometer (into or out of the stream or lake) and record this observation on the field form.

6.17.7.19 When the measurements are complete, proceed with thermistor downloads (see Bilhimer and Stohr, 2007 for details) or water quality sampling as appropriate[7]. When done return any continuous data instrumentation to its correct position in the piezometer, note the reinstall time on the field form, and re-cap the casing.

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[7] The order of these steps can be rearranged to accommodate the needs of individual piezometers. For example thermistors can be download while waiting for the piezometer water level to stabilize after removing the cap or attaching an extension. The important thing is to complete all the indicated steps.

6.18 Decommissioning Piezometers

6.19 The project engineer or hydrogeologist must file a "Notice of Intent to Decommission a Well" form with the regional Water Resources Program office, at least 72 hours before removing (decommissioning) a piezometer (See Appendix A for additional details). The intended decommissioning procedure(s) should follow those outlined in the project well construction variance.

6.20 Depending on local site conditions steel piezometers are most commonly removed by:

6.20.1 Twisting and pulling the casing with opposed pipe wrenches,

6.20.2 Attaching chains or a star-clamp assembly to the casing and extracting it with high-lift jacks, or

6.20.3 Back hammering against a star clamp assembly with sledge hammers.

6.21 <u>High-lift jacks and sledge hammers exert considerable force on piezometer pipes, couplers, and related equipment. Avoid injuring yourself or others by always working safely (wear proper eye, head, and hand protection) and communicating your intentions with fellow workers.</u>

6.22 Always use two jacks to decommission a steel piezometer - each with an attached 3-4 foot length of heavy gage chain. This arrangement spreads the load between jacks and minimizes the potential for bent casing, or jack slippage during extraction.

6.23 Start by placing the jacks on opposite sides of the casing. In soft sediment support the foot of each jack with a piece of heavy plywood or a short length of 2 by 8 lumber. Wrap each of the jack chains around the casing several times and then pull them tight to hold the jacks and casing in close contact (Figure 12). If possible wrap the chain around the lowermost casing rather than a casing extension(s) to avoid placing too much strain on pipe threads or couplers.

6.23.1 Secure the loose end of each chain to its corresponding jack with a chain hook.

6.23.2 Tightly wrap a third length of chain around the casing and the two jack bases and secure with a chain hook.

6.23.3 Set the jack direction lever to the lift position. With a person operating each jack slowly raise the jack heads until the chains snug tightly around the casing. Continue working the jacks in unison, applying just enough pressure to extract the casing. (Note: For stuck or difficult to remove casings, try tapping the piezometer cap with a 2-pound hand sledge while applying upward force with the jacks. This often helps to get the casing moving).

Figure 12 - Decommissioning a steel piezometer with high-lift jacks

6.23.4 PVC cased piezometers can generally be removed by hand or by carefully twisting and pulling with pipe wrenches.

6.23.5 Likewise, tubing piezometers can often be pulled by hand. When they can't, cut the tubing off 6-12 inches below the sediment surface, plug the exposed end, and refill the excavation with sediment.

6.23.6 After the casing has been removed, fill any hole that remains with fine sediment. If the project well construction/decommissioning variance specifies additional abandonment steps, proceed with and document the procedure(s) on the well decommissioning form.

6.23.7 Remove the well tag from the piezometer casing and submit it to Ecology's Water Resources program along with the completed well decommissioning form.

7.0 Record Management

7.1 The In-water piezometers that EAP installs or monitors must be documented to enable information about their location, construction, and subsequent monitoring to be archived in Ecology's Environmental Information Management (EIM) system and well log imaging databases. Consult the EIM help documents and EAP SOP-052 subsection 7.0 (Marti, 2009) for a list of the well specific metadata required by EIM.

7.2 Station information and monitoring notes should be documented, during each site visit, using EAP's standard piezometer field forms (or equivalent) (Appendix A). All field entries should be neat and concise. The field lead is responsible for reviewing the form(s) for completeness before leaving a field site.

7.3 Data Processing

7.3.1 EAP staff have developed a number of data analysis spreadsheets, field forms, and other tools to standardize data collection and processing for projects involving in-water piezometers. See the EAP GW TCT website for the most up-to-date version of these tools.

7.3.2 See Bilhimer and Stohr, 2007 for additional guidance about managing and processing the continuous temperature data collected at in-water piezometer sites.

7.4 Field Form Archives

7.4.1 All original field forms (including piezometer installation forms, well reports, routine monitoring, and decommissioning forms) should be compiled in a project notebook and retained in the permanent project archive.

8.0 Quality Control and Quality Assurance

8.1 The following general quality assurance/quality control (QA/QC) procedures apply:

8.1.1 All personnel installing and monitoring in-water piezometers must adhere to EAP's standard operating procedures (SOP) for data collection involving piezometers (this document) as well as the SOP's for monitoring surface water temperatures (Bilhimer and Stohr, 2007) and the procedures for measuring water levels and calibrating water level meters (Marti, 2009).

8.1.2 All instrumentation must be operated in accordance with the operating instructions supplied by the manufacturer, unless otherwise specified in the project's Quality Assurance Project Plan (QAPP).

8.1.3 Repeat measurements of the well depth or depth-to-water at each location must be made to ensure reproducibility and accuracy. Repeat measurements should be within the method's specified accuracy standards. If repeated check measurements are not reproducible, then a reason must be established and documented.

8.1.4 All data and other measurements must be documented and permanently archived on project field data forms.

9.0 Safety

9.1 Installing and monitoring in-water piezometers can pose significant risks to field personnel. Take these hazards seriously. When appropriate, use work gloves, safety glasses, hard hats, hearing protection, and steel-toed boots. Personal flotation devices are required for persons working in or near surface water.

9.2 Do not enter water that is too deep or swift for safe entry and exit.

9.3 Use common sense, work in teams, and read and follow the procedures outlined in the EAP Safety Manual for in-water work.

9.4 Always consider the safety and traffic situations when accessing a stream or lake from highway bridges. Consult the EAP Safety Manual for further guidance regarding bridge safety.

9.5 The following forms must be completed to document field personnel, sampling locations, overnight lodging, planned itinerary, contact person(s), and emergency contacts:

9.5.1 Float plan Form (if using a boat to access sites)

9.5.2 Field Work Plan and Contact Person Form

10.0 References

10.1 Bilhimer, D., and Stohr, A., 2007, Standard Operating Procedures for continuous temperature monitoring of fresh water rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature. Environmental Assessment Program, EAP044, Version 2.2. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_044Cont_Temp_Monit_TMDL.pdf

10.2 Cardenas, M.B., and Zlotnik, V.A., 2003, A simple constant-head injection test for streambed hydraulic conductivity estimation, Ground Water, Vol. 41, No. 6, p. 867-871.

10.3 Janisch, J., 2006, Standard operating procedure for determining coordinates via hand-held GPS receivers. Washington State Department of Ecology, Environmental Assessment Program, EAP013, Version 1.0.

10.4 Konrad, C. P., 2006, Location and timing of river-aquifer exchanges in six tributaries to the Columbia River in the Pacific Northwest of the United States, Journal of Hydrology 329, p. 444– 470.

10.5 Marti, P.B., 2009, Standard operating procedure for manual well-depth and depth-to-water measurements. Washington State Department of Ecology, Environmental Assessment Program, EAP052, Version 1.0. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_052ManualWellDepth&DepthtoWaterMeasures_v_1_0.pdf

10.6 Pitz, C.F., 2006, An evaluation of a piezometer-based constant head injection test (CHIT) for use in groundwater/surface water interaction studies, Washington State Department of Ecology, Publication No. 06-03-042, 31 p. http://www.ecy.wa.gov/biblio/0603042.html

10.7 Rosenberry, D.O., and LaBaugh, J.W., 2008, Field techniques for estimating water fluxes between surface water and ground water: U.S. Geological Survey Techniques and Methods 4–D2, 128 p. http://pubs.usgs.gov/tm/04d02/pdf/TM4-D2ALL.pdf

10.8 Stonestrom, D.A., and Constantz, J.E., eds., 2003, Heat as a tool for studying the movement of ground water near streams: U.S. Geological Survey Circular 1260, 96 p. http://pubs.usgs.gov/circ/2003/circ1260/pdf/Circ1260.pdf

10.9 Washington State Department of Ecology, Environmental Assessment Program, 2009, Safety Manual. 192 p. http://aww.ecology/programs/eap/Safety/Safety1.html

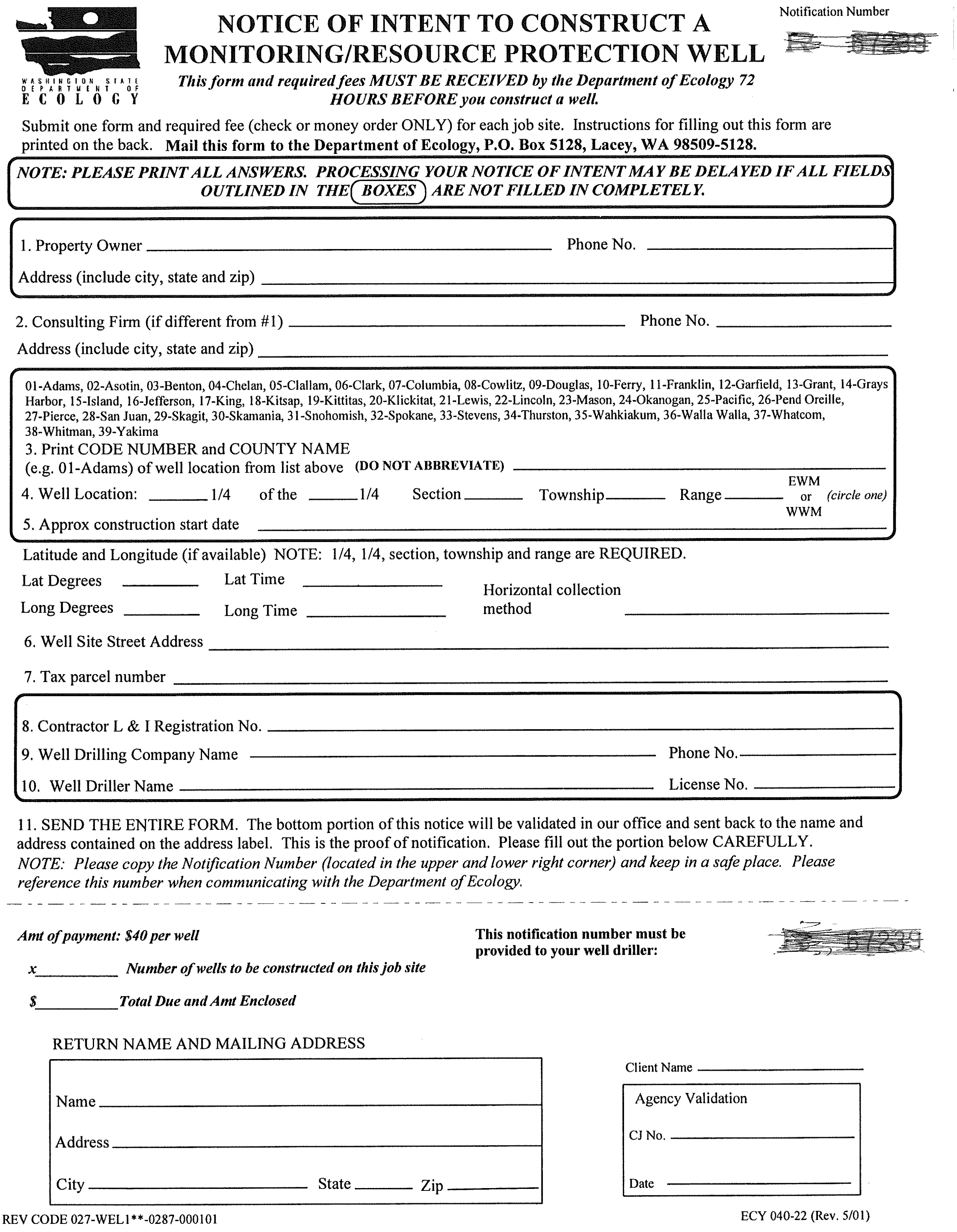
10.10 Winter, T.C., Harvey, J.W., Franke, O.L., and W.M. Alley, 1998. Ground water and surface water – a single resource, U.S. Geological Survey Circular 1139, 79 pp. http://pubs.usgs.gov/circ/circ1139/

10.11 Winter, T.C, Labaugh, J.W., and Rosenberry, D.O., 1988, The design and use of a hydraulic potentiomanometer for direct measurement of differences in hydraulic head between groundwater and surface water, Limnol. Oceanogr., Vol. 33, No. 5, p. 1209-1214. http://new.aslo.org/lo/toc/vol_33/issue_5/1209.pdf

Appendix A: Example Forms

EAP has developed several spreadsheet templates to speed and where possible automate the repetative tasks required to install and monitor in-water piezometers. Examples of commonly used forms are included here. See EAP's GW TCT (Technical Coordination Team) Sharepoint site for up-to-date versions of field forms, data analysis spreadsheets, and other helpful tools.

Example Form – Notice of Intent to Construct a Resource Protection Well



WASHINGTON STATE DEPARTMENT OF ECOLOGY

Notification Number [redacted]

NOTICE OF INTENT TO CONSTRUCT A MONITORING/RESOURCE PROTECTION WELL

This form and required fees MUST BE RECEIVED by the Department of Ecology 72 HOURS BEFORE you construct a well.

Submit one form and required fee (check or money order ONLY) for each job site. Instructions for filling out this form are printed on the back. **Mail this form to the Department of Ecology, P.O. Box 5128, Lacey, WA 98509-5128.**

NOTE: PLEASE PRINT ALL ANSWERS. PROCESSING YOUR NOTICE OF INTENT MAY BE DELAYED IF ALL FIELDS OUTLINED IN THE BOXES ARE NOT FILLED IN COMPLETELY.

1. Property Owner ____________ Phone No. ____________
Address (include city, state and zip) ____________

2. Consulting Firm (if different from #1) ____________ Phone No. ____________
Address (include city, state and zip) ____________

01-Adams, 02-Asotin, 03-Benton, 04-Chelan, 05-Clallam, 06-Clark, 07-Columbia, 08-Cowlitz, 09-Douglas, 10-Ferry, 11-Franklin, 12-Garfield, 13-Grant, 14-Grays Harbor, 15-Island, 16-Jefferson, 17-King, 18-Kitsap, 19-Kittitas, 20-Klickitat, 21-Lewis, 22-Lincoln, 23-Mason, 24-Okanogan, 25-Pacific, 26-Pend Oreille, 27-Pierce, 28-San Juan, 29-Skagit, 30-Skamania, 31-Snohomish, 32-Spokane, 33-Stevens, 34-Thurston, 35-Wahkiakum, 36-Walla Walla, 37-Whatcom, 38-Whitman, 39-Yakima

3. Print CODE NUMBER and COUNTY NAME
(e.g. 01-Adams) of well location from list above **(DO NOT ABBREVIATE)** ____________

4. Well Location: ______ 1/4 of the ______ 1/4 Section ______ Township ______ Range ______ EWM or WWM *(circle one)*

5. Approx construction start date ____________

Latitude and Longitude (if available) NOTE: 1/4, 1/4, section, township and range are REQUIRED.

Lat Degrees ______ Lat Time ______
Long Degrees ______ Long Time ______
Horizontal collection method ______

6. Well Site Street Address ____________

7. Tax parcel number ____________

8. Contractor L & I Registration No. ____________

9. Well Drilling Company Name ____________ Phone No. ____________

10. Well Driller Name ____________ License No. ____________

11. SEND THE ENTIRE FORM. The bottom portion of this notice will be validated in our office and sent back to the name and address contained on the address label. This is the proof of notification. Please fill out the portion below CAREFULLY.
NOTE: Please copy the Notification Number (located in the upper and lower right corner) and keep in a safe place. Please reference this number when communicating with the Department of Ecology.

Amt of payment: $40 per well

x ______ ***Number of wells to be constructed on this job site***

$ ______ ***Total Due and Amt Enclosed***

This notification number must be provided to your well driller: [redacted]

RETURN NAME AND MAILING ADDRESS

Name ____________
Address ____________
City ____________ State ______ Zip ______

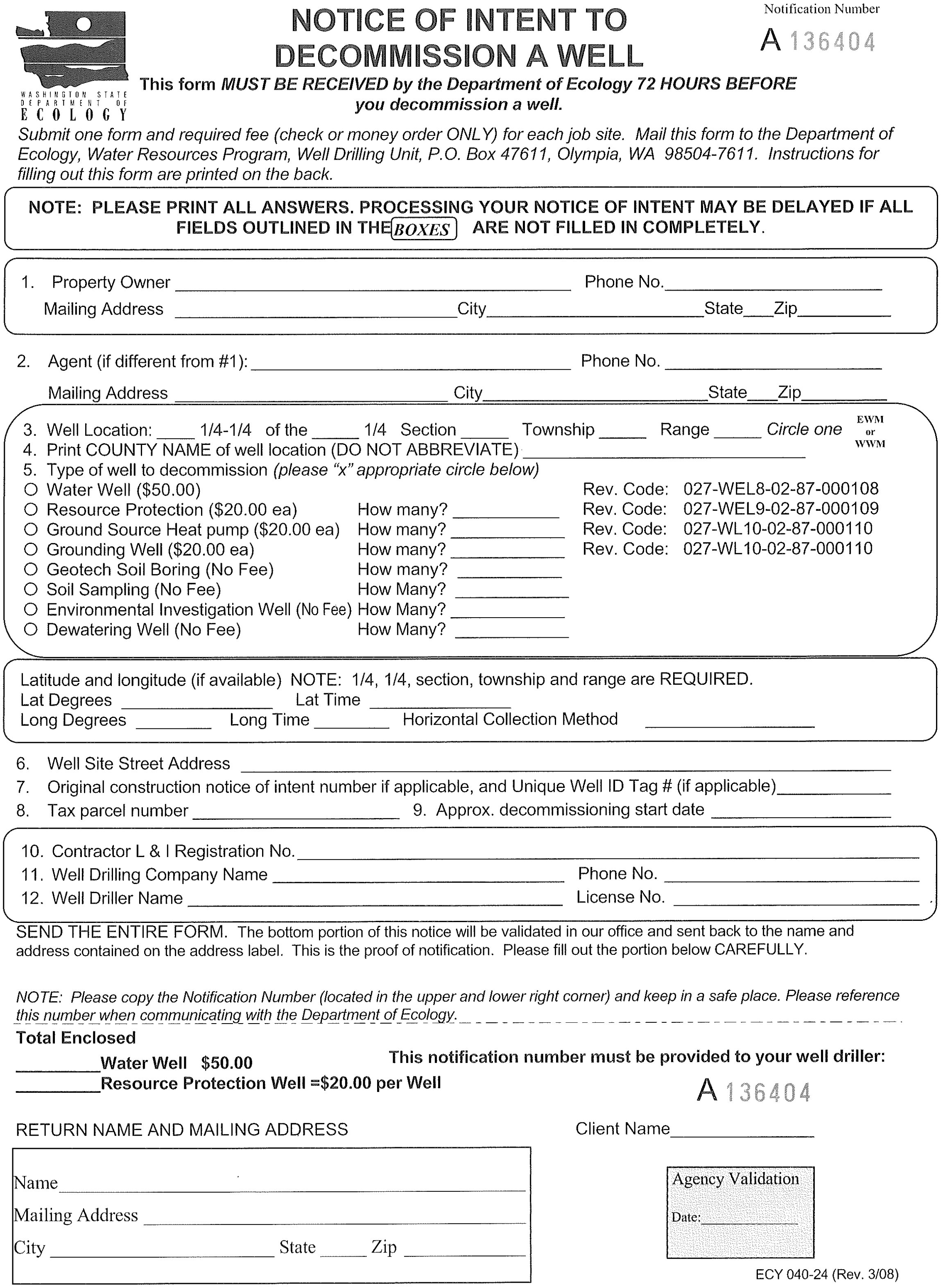
Client Name ____________

Agency Validation
CJ No. ____________
Date ____________

REV CODE 027-WEL1**-0287-000101

ECY 040-22 (Rev. 5/01)

Example Form – Notice of Intent to Decommission a Well



WASHINGTON STATE DEPARTMENT OF ECOLOGY

NOTICE OF INTENT TO DECOMMISSION A WELL

Notification Number
A 136404

This form *MUST BE RECEIVED by the Department of Ecology 72 HOURS BEFORE you decommission a well.*

Submit one form and required fee (check or money order ONLY) for each job site. Mail this form to the Department of Ecology, Water Resources Program, Well Drilling Unit, P.O. Box 47611, Olympia, WA 98504-7611. Instructions for filling out this form are printed on the back.

NOTE: PLEASE PRINT ALL ANSWERS. PROCESSING YOUR NOTICE OF INTENT MAY BE DELAYED IF ALL FIELDS OUTLINED IN THE *BOXES* ARE NOT FILLED IN COMPLETELY.

1. Property Owner ____________________ Phone No.____________
Mailing Address ________________City____________State___Zip_______

2. Agent (if different from #1): ____________________ Phone No. ____________
Mailing Address ________________City____________State___Zip_______

3. Well Location: ____ 1/4-1/4 of the _____ 1/4 Section _____ Township _____ Range _____ *Circle one* EWM or WWM
4. Print COUNTY NAME of well location (DO NOT ABBREVIATE) ____________________
5. Type of well to decommission *(please "x" appropriate circle below)*

○ Water Well ($50.00)		Rev. Code: 027-WEL8-02-87-000108
○ Resource Protection ($20.00 ea)	How many? ________	Rev. Code: 027-WEL9-02-87-000109
○ Ground Source Heat pump ($20.00 ea)	How many? ________	Rev. Code: 027-WL10-02-87-000110
○ Grounding Well ($20.00 ea)	How many? ________	Rev. Code: 027-WL10-02-87-000110
○ Geotech Soil Boring (No Fee)	How many? ________	
○ Soil Sampling (No Fee)	How Many? ________	
○ Environmental Investigation Well (No Fee)	How Many? ________	
○ Dewatering Well (No Fee)	How Many? ________	

Latitude and longitude (if available) NOTE: 1/4, 1/4, section, township and range are REQUIRED.
Lat Degrees ____________ Lat Time ____________
Long Degrees ________ Long Time ________ Horizontal Collection Method ____________

6. Well Site Street Address ____________________
7. Original construction notice of intent number if applicable, and Unique Well ID Tag # (if applicable)________
8. Tax parcel number ______________ 9. Approx. decommissioning start date ____________

10. Contractor L & I Registration No.____________________
11. Well Drilling Company Name ________________ Phone No. ____________
12. Well Driller Name ________________ License No. ____________

SEND THE ENTIRE FORM. The bottom portion of this notice will be validated in our office and sent back to the name and address contained on the address label. This is the proof of notification. Please fill out the portion below CAREFULLY.

NOTE: Please copy the Notification Number (located in the upper and lower right corner) and keep in a safe place. Please reference this number when communicating with the Department of Ecology.

Total Enclosed

________**Water Well $50.00**
________**Resource Protection Well =$20.00 per Well**

This notification number must be provided to your well driller:
A 136404

RETURN NAME AND MAILING ADDRESS

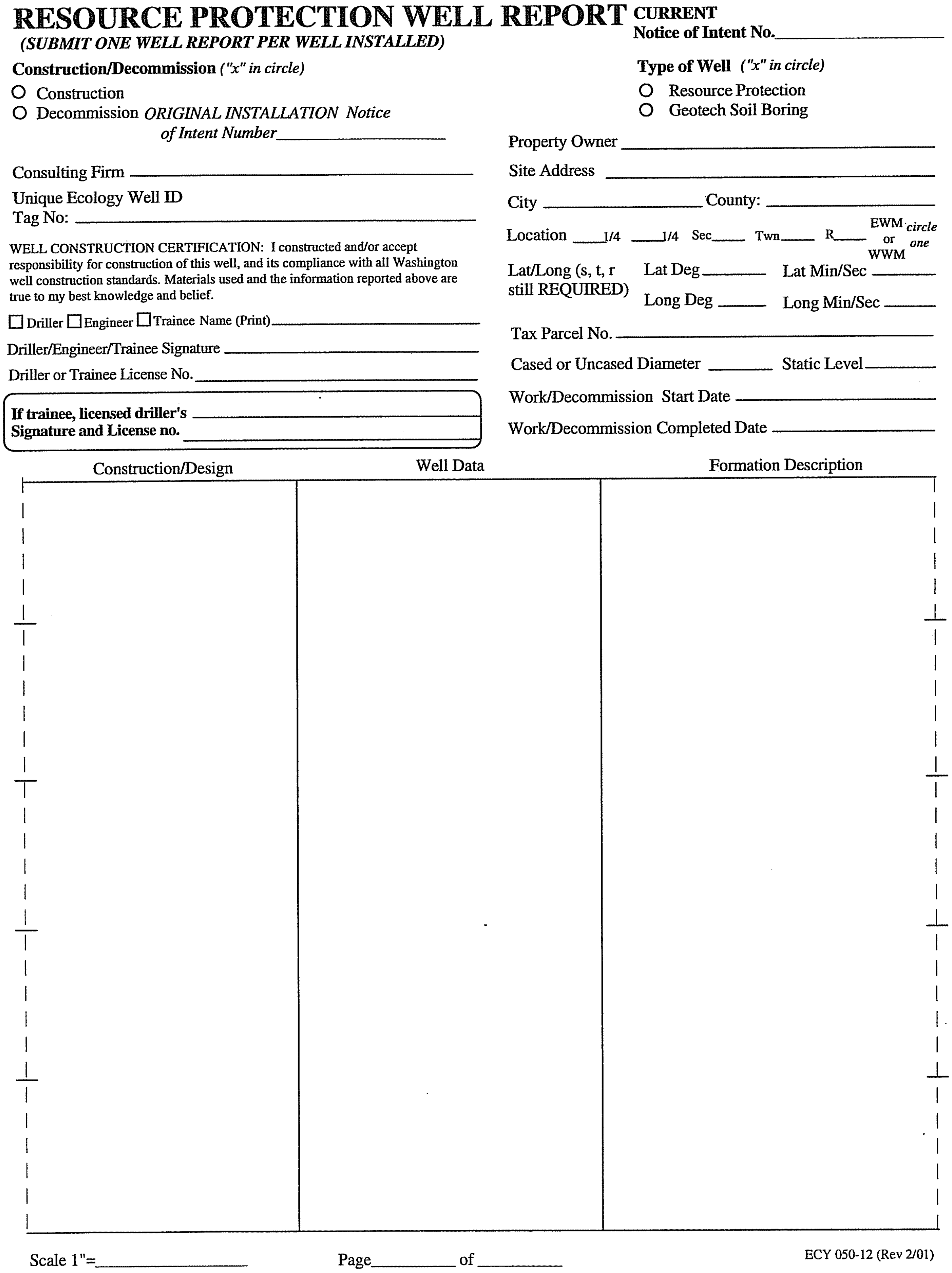
Name ____________________
Mailing Address ____________________
City ______________ State _____ Zip ________

Client Name____________

Agency Validation
Date:__________

ECY 040-24 (Rev. 3/08)

Example Form –Resource Protection Well Completion Report



RESOURCE PROTECTION WELL REPORT **CURRENT**

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

Notice of Intent No.

Construction/Decommission *("x" in circle)*

○ Construction

○ Decommission *ORIGINAL INSTALLATION Notice of Intent Number*

Type of Well *("x" in circle)*

○ Resource Protection

○ Geotech Soil Boring

Property Owner

Site Address

City County:

Location 1/4 1/4 Sec Twn R EWM or WWM *circle one*

Lat/Long (s, t, r still REQUIRED) Lat Deg Lat Min/Sec

Long Deg Long Min/Sec

Tax Parcel No.

Cased or Uncased Diameter Static Level

Work/Decommission Start Date

Work/Decommission Completed Date

Consulting Firm

Unique Ecology Well ID Tag No:

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☐ Driller ☐ Engineer ☐ Trainee Name (Print)

Driller/Engineer/Trainee Signature

Driller or Trainee License No.

If trainee, licensed driller's Signature and License no.

Construction/Design	Well Data	Formation Description

Scale 1"= Page of

ECY 050-12 (Rev 2/01)

Example Form – Piezometer Site Reconnaissance

Piezometer Reconnaissance Field Sheet

Date: ____________ **Time:** ______________

Field Crew: ______________

Stream/River Name: ______________________

Location/Access Description: ______________

____

____

____

____

____

Preliminary GPS Coordinates

Recording Datum: **NAD83HARN** ☐ **NAD83** ☐ **NAD27** ☐

DDLAT: ____________ **DDLONG:** ____________

Adjacent Property Ownership Info:

Name: ___________________________

Address: ___________________________

Phone: ______________________

Permission Granted? ☐

Property Access Notes: ____________________

____

____

Name: ___________________________

Address: ___________________________

Phone: ______________________

Permission Granted? ☐

Property Access Notes: ____________________

____

____

Recon Photo #: __________________

Add sketch map of recon location on back
Piezometer Reconnaissance Field Sheet

Example Form - Piezometer Installation, No Thermistors

GPS Location - NAD 27 / NAD 83

DD Lat: ____________________

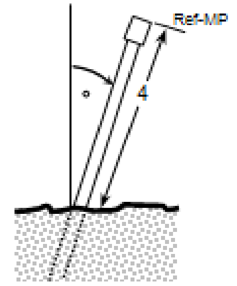
DD Long: ____________________

Site Description/Bearing Info: ____________________

____

____

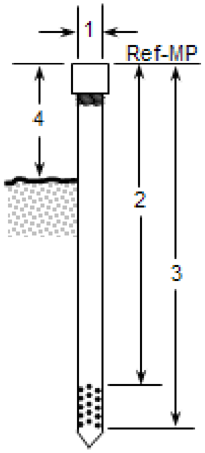
Substrate: ____________________________________



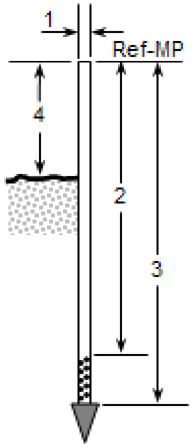
Piezo incline from vertical

°

____



Pipe Piezo



Tubing Piezo

1 – Casing or Tubing Diameter *	ft
2 – Length from Ref-MP to top of open interval *	ft
3 – Length from Ref-MP to bottom of open interval *	ft
4 – Stickup length – from Ref-MP to streambed (after installation; along pipe)	ft

**Measure these lengths BEFORE piezometer installation*

Reference Measuring Point (Ref-MP) Notes

____

Piezometer Open Interval Notes

Piezometer/Open Interval Type:

- ☐ Metal pipe/drilled or perforated
- ☐ Well point/manufactured screen
- ☐ Poly tubing/filter fabric

Open Interval Description

____

____

____

____

Piezometer Development Notes

____

____

____

____

Site Photo Notes

____

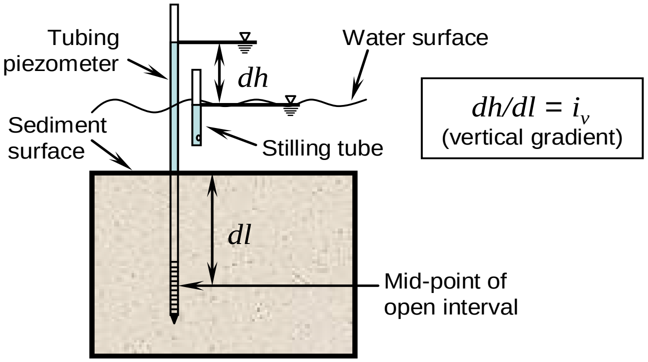
____

Example Form – Manometer Measurement

Tubing Piezometer Measurement

Stickup Length (measuring point to streambed) ___________

GW/SW Head Difference __________ **(*dh*)**



Manometer board measurements

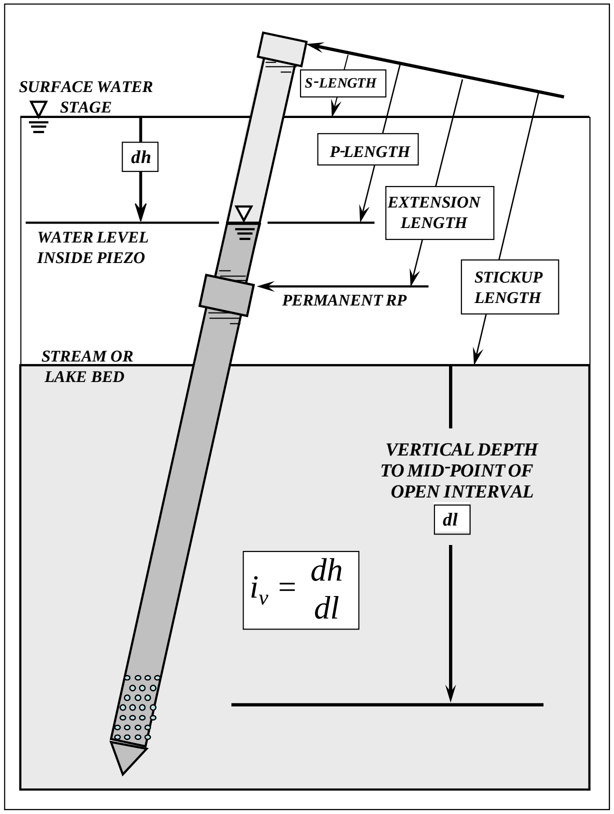
Surface Water (cm)	Piezometer (cm)	Head Difference (SW – Piezo)

Example Form – Manual Water Level Measurement

Piezometer Water Level Field Sheet (Hand)

Date: __________**Time:**__________**Crew:**________________

Tag ID: ______________**Piezo Name:**____________________

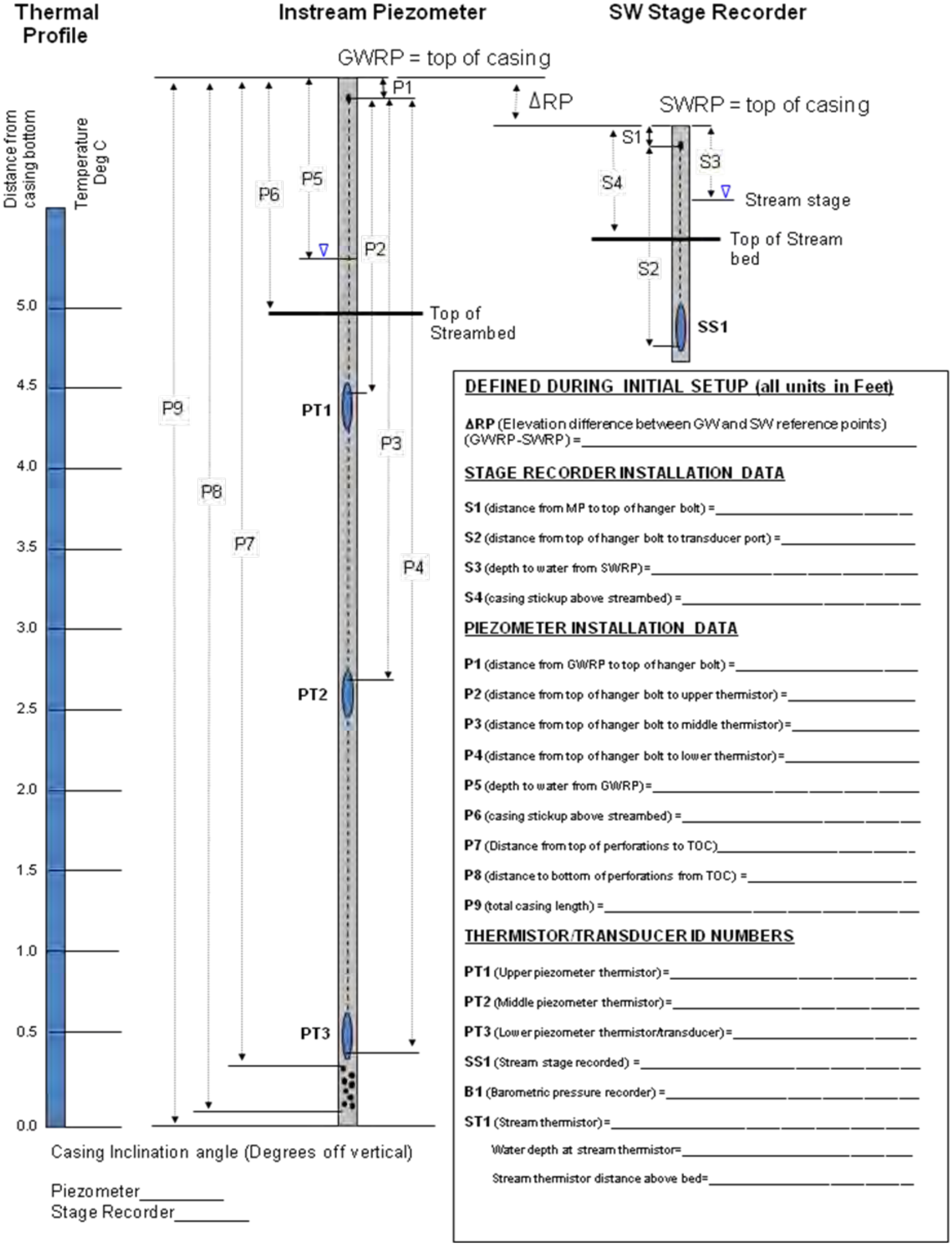


Water Level MP: TOC other:_________________________

E-tape #:	Hold	Cut
S-Length	ft	ft
P-Length	ft	ft
Extension Length	ft	ft
Stickup Length	ft	ft
Total Interior Length	ft	ft

Measure inclined lengths, not corrected vertical heights

Example Form – Piezometer Installation Including Thermistors and/or Water Level Transducers



Casing Inclination angle (Degrees off vertical)

Piezometer_________

Stage Recorder_________

DEFINED DURING INITIAL SETUP (all units in Feet)

ΔRP (Elevation difference between GW and SW reference points) (GWRP-SWRP) =_______________________________

STAGE RECORDER INSTALLATION DATA

S1 (distance from MP to top of hanger bolt) =_______________________

S2 (distance from top of hanger bolt to transducer port) =_________________

S3 (depth to water from SWRP) =_______________________________

S4 (casing stickup above streambed) =____________________________

PIEZOMETER INSTALLATION DATA

P1 (distance from GWRP to top of hanger bolt) =______________________

P2 (distance from top of hanger bolt to upper thermistor) =_________________

P3 (distance from top of hanger bolt to middle thermistor) =________________

P4 (distance from top of hanger bolt to lower thermistor) =_________________

P5 (depth to water from GWRP) =______________________________

P6 (casing stickup above streambed) =____________________________

P7 (Distance from top of perforations to TOC)_______________________

P8 (distance to bottom of perforations from TOC) =____________________

P9 (total casing length) =_________________________________

THERMISTOR/TRANSDUCER ID NUMBERS

PT1 (Upper piezometer thermistor) =__________________________

PT2 (Middle piezometer thermistor) =__________________________

PT3 (Lower piezometer thermistor/transducer) =____________________

SS1 (Stream stage recorded) =_____________________________

B1 (Barometric pressure recorder) =___________________________

ST1 (Stream thermistor) =_________________________________

Water depth at stream thermistor=__________________________

Stream thermistor distance above bed=_______________________

Appendix B: Permit Requirements and Procedural Checklist for Installing and Decommissioning In-water Piezometers

This checklist was prepared to help workers complete the required forms and environmental permit applications for projects where piezometers or other hydraulic monitoring devices are deployed within lake, stream, or other waterbody. Be advised that some projects may require additional local, state, and/or federal permits/exemptions beyond those discussed here.

Piezometer Installation

JARPA application

If you intend to install or anchor monitoring equipment in a stream or lake you must file a JARPA (Joint Aquatic Resource Permit Application) application for your project (http://www.ecy.wa.gov/programs/sea/pac/index.html). The JARPA application is intended to streamline the permitting process by enabling workers to apply for most common environmental permits using a single application form. See the GWTCT website for an example JARPA application. At a minimum use the JARPA application to secure a hydraulics project approval (HPA), shorelines permit exemption, and to declare your project's categorical exemption from SEPA if appropriate (hydraulic monitoring devices are exempt from SEPA oversight). If you will be working in "navigable waters of the state" you must also complete an Aquatic Lands Right of Entry Agreement with WADNR as part of the JARPA process.

Per the JARPA instructions forward signed copies of the completed application to the county shorelines administrator (usually the planning department) for each county you will be working in. Forward another copy to the WDFW district/regional office that has jurisdiction over your project area (see map below).

Many counties charge a fee to process the shorelines exemption paperwork. Use an A19 form (http://aww.ecology/forms/forms_toc.htm#financial) to pay this fee.

Underground Utility Location Services

To ensure that you will not damage buried power lines, gas lines, fiber optic cables, or other utilities, call the underground utility location service to identify utility locations in the vicinity of your proposed piezometer sites (http://www.callbeforeyoudig.org/). Allow 3-5 working days for utility locations to be marked.

Well construction/decommissioning paperwork requirements

A "notice of intent to construct a resource protection well" form must be filed with Ecology's water resources program at least 72 hours before installing the first piezometer for a project. There is a $10 fee for each temporary piezometer (those where no casing is left in the ground) and a $40 fee for each permanent piezometer (those where casing is left in place). A separate notice form is required for each quarter/quarter section (40 acre area) where you plan to install piezometers. Use an A19 form (http://aww.ecology/forms/forms_toc.htm#financial) to pay start card fees.

Piezometer installation must be done by a licensed well driller or under the direct oversight of a licensed engineer.

Each permanent piezometer must be physically tagged with a unique well ID tag. Obtain well tags from Ecology's well drilling coordinator (HQ water resources program).

Temporary piezometers should also be assigned a tag ID to facilitate data entry into Ecology's well log and EIM databases. Be sure to destroy the tag for any temporary piezometers that are installed to prevent them from accidently being reassigned to another piezometer.

A well log must be completed for each piezometer (either permanent or temporary) and submitted to the appropriate Ecology regional office within 30 days of piezometer installation. Blank well log forms are available from Ecology's well drilling coordinator (HQ water resources program). Be sure to include the unique well ID tag number on each well log.

When the piezometers are no longer needed, file a "notice of intent to decommission a well" form for each piezometer that will be removed. Use a single A-19 form to pay the total decommissioning cost for the project (see Table 2). Complete and file a well decommissioning report form with Ecology's Water Resources Program for each piezometer you remove (see example form in Appendix A).

Table B1 - Summary of permits and approval requirements for in-water piezometers

Application/action	**Permit/document Type**	**Lead Agency/ Authority**	**Estimated Fee/Cost**	**Approximate timeline for issuance/action**
Non-Ecology permits/approvals that must be obtained prior to installing piezometers[1]				
JARPA	HPA	WADFW-regional office	None	15-30 days after shorelines permit issues
JARPA	Shorelines Exemption	County planning department	None-$200+	30-60 days after completed app. received.
JARPA	SEPA - categorical exemption	County planning department	None	NA - part of JARPA application
JARPA	Aquatic lands right of entry agreement	WADNR - regional office	Notary public fees may apply in some cases.	20-30 days
Utilities Underground Location Center (UULC)	None- field location of underground utilities	UULC 1-800-424-5555 See UULC web site for details.	None	Allow 3-5 business days for response.
Ecology well construction/abandonment notices, variances, and related paperwork[2]				
Memo requesting a well construction variance	Well construction variance letter	Ecology regional office - water resources program	None	Submit variance request at least 3 months before project start date.
Submit notice of intent to construct a monitoring / resource protection well	A separate notice is required for each section and quarter/quarter	Ecology - water resources via purchasing unit	$10-$40 per piezometer (see next item)	Submit notice at least 72 hours before installing first piezometer
File a completed A-19 form with your notice of intents (submit both to Ecology's purchasing unit in fiscal)	A-19 (one per project)	Project manager	$10 / non-cased $40 / cased piezometer	Submit one A-19 form per project with notice of intent(s)
Submit well completion report(s)	One completion report (well log) per piezometer	Ecology water resources	None	Submit well log(s) within 30 days of well installation
Submit notice of intent to abandon a well	A separate notice is required for each piezometer	Ecology - water resources	$0-$20 per piezometer (see next item)	Submit notice at least 72 hours before decommissioning first piezometer
File an A-19 form with the notices of intent to decommission a well - submit both to Ecology's purchasing unit	A-19 (one per project)	Project manager	$0 / non-cased $20 /cased piezometer	Submit one A-19 form per project with notice of intent(s)
Submit decommissioning report(s)	One report per piezometer	Ecology water resources	None	Submit report within 30 days of well decommissioning

[1] EAP currently has a procedure in place to streamline permit acquisition, see the groundwater TCT website for details.

[2] (see Chapter 173-160 WAC for the most up to date guidance on these and other well related requirements)

CHAIN-OF-CUSTODY AND SAMPLE LABELING

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Suzanne Dolberg	Craig Christian	5/19/2009		

This Standard Operating Procedure (SOP) contains nine sections:

1. Purpose

The purpose of this SOP is to provide field personnel and other individuals involved in sample handling a set of procedures to ensure proper documentation of samples during transfer to maintain defensible chain-of-custody.

2. Application

This SOP is applicable to field programs involving sample collection and transfer of samples outside of field team personnel direct control (e.g., shipped from field to laboratory). On-site analysis programs generally do not require full chain-of-custody (COC) transfer procedures unless samples are not securely maintained under field team personnel control (e.g. overnight storage prior to analysis). If samples are not securely maintained under field team personnel control during an on-site analysis program, follow the custody procedures described in this SOP.

3. References

Consult the site-specific Sampling and Quality Assurance Plan (SQAP) for modifications that may be necessary to these procedures. Determine appropriate PPE for use in conjunction with this SOP based on the site-specific Health and Safety Plan (HASP).

4. Associated SOPs

EI-1008	Field Equipment Decontamination
EI-4014	Field Documentation and Forms
EI-4034	Environmental Sample Packaging and Shipping

5. Equipment

The following equipment should be brought with the field sampling team:

- Gloves (generally Nitrile but other materials may be acceptable based on SQAP or HASP requirements)
- PPE required per the HASP or SQAP based on site-specific hazards
- Chain-of-custody forms – see Attachment 1
- Chain-of-custody seals
- Sample labels
- Sample tags, as required
- Ball point pens
- Fine point permanent markers (e.g., Sharpies)
- Clear shipping tape
- Forms II Lite™ software
- Computer and Printer
- Blank labels for use in a printer.

6. Decontamination

Decontamination procedures will be followed in accordance EI-1008, if necessary (e.g., sample spillage).

7. Documentation Procedures

7.1 Chain-of-Custody

COC procedures provide a record of sample collection, transfer of samples, sample shipping, and receipt to ensure and document sample integrity.

Samples are in custody when:

1. in physical possession of field team member;
2. in view of a field team member, after being in physical possession; or
3. secured to prevent tampering after being in physical possession of a field team member in secure area restricted to authorized personnel only.

To maintain sample integrity, samples must be under documented control of field team personnel or secured from any possible tampering (i.e., locked or under COC seal).
Sample collection is documented in sample labels, tags and field books and field forms (see SOP No. EI-4014 for sample documentation procedures). COC forms document transfers of the samples and the responsibility for secure control of the sample integrity.

A written COC form must be initiated and thereafter maintained whenever samples must be transferred beyond control of the site-specific field team such as when samples are shipped to a laboratory. A COC form serves as legal evidence of possession of the samples and documents the conditions and integrity with which the samples were handled.

7.2 Initiating Chain-of-Custody Documentation

The COC form must be initiated with, or as soon as practicable after, sample collection and prior to any transfer of sample control beyond the site specific field team. For United States Environmental Protection Agency (EPA) projects where the samples are to be transferred to a Contract Laboratory Program (CLP) laboratory, the COC must be generated using EPA's Field Operations and Records Management System (FORMS) II Lite™ software prior to entering the field to sample. EPA projects may constitute the use of FORMS II Lite™ for tracking samples regardless of whether or not the samples will be submitted to a CLP laboratory.

For non-EPA projects, the COC form may be provided by the laboratory or a generic EI COC may be used in its place. See Attachment 1 for the generic EI COC form.

Once initiated, the COC form remains with the samples bearing the name of the person assuming responsibility for the samples. Since the COC form must accompany samples, the COC forms may be completed in conjunction with sample container packing to ensure that all samples contained in sample shipment containers (i.e., coolers) are contained on the same COC. When COC forms are completed during sample packing, sample collection notes such as date and time must be made during sample collection and maintained as part of the site record in bound logbooks or sample collection forms (see EI 4014 Field Documentation and Forms). COC forms do not replace documentation of sample collection but document the transfer of collected samples.

7.3 COC Information

The COC, in addition to establishing custody of samples, provides the laboratory or other recipient with information for proper sample handling and analysis. The COC should contain a minimum of the following general information:

- Project name;
- EI contact name, phone, email;
- Any special sample handling instructions (e.g., filter, short turnaround requests, or possible high hazard waste samples); and
- Shipping air bill or tracking number, as necessary

The COC must also contain the following specific information for each sample:

- Sample ID – refer to the site-specific SQAP for sample ID format;
- Date and time of collection;
- Sample matrix;
- Number and type of containers; and
- Analyses to perform.

An example COC form is included in Attachment 1.

7.4 Transfer of Custody

All sample transfers beyond the site-specific field team must be accompanied by a COC. Transfer of samples within the field team do not require a COC form (for example, transfer from sample collector to central area for COC preparation). When shipping the samples, the field team member responsible for packing the samples for shipment may indicate transfer by including the shipping company, date/time of shipment, and air bill or shipping number within a properly COC sealed shipping container (see section 7.5). If the samples are being picked up by a courier for immediate delivery, the courier must sign, date, and time the COC as an individual if the cooler is not COC sealed. When transferring possession of the samples, the individual receiving samples should sign, date, and time the COC when they receive the samples.

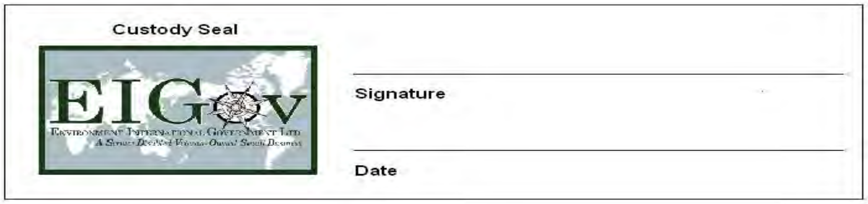
After signatures and dates of transfer are complete, the field team member responsible for packing the samples will make a copy of the COC. The original, signed copy will be placed in a waterproof plastic bag and taped to the inside top of the shipping container lid. The container will then be secured with nylon strapping tape and custody seals applied as described in Section 7.5.

The retained copy will immediately become part of the project file. The original will be returned to EI as part of the analytical data package. Other copies may be maintained by the laboratory.

7.5 Chain-of-Custody Seals

The COC seals are adhesive labels that are placed on the exterior sample container or shipping container in such a manner that the container cannot be opened without breaking the seals. The COC seal helps ensure that no sample tampering occurs during transit. COC seals are signed and dated by the field team member responsible for packing the samples. If seals are received broken at the laboratory, the laboratory will alert the EI contact within 24 hours of receipt of the container. The project manager will then follow the corrective action procedures designated in the site-specific SQAP. For additional security, COC seals will be used on shipping containers and may also be placed on each individual sampling container if required by the SQAP. See Figures 1 and 2 for an example COC seal and proper placement of seals on the cooler.

Figure 1: Custody Seal



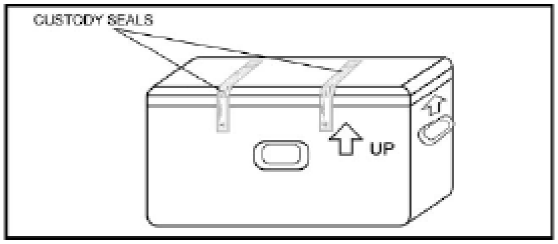
Custody Seal

EIGov

Signature

Date

Figure 2: Custody Seal Placement



7.6 Sample Labels and Tags

A sample label (see Figure 3) will be placed on each sample container at or before the time of sample collection.

Figure 3: Sample Label

EIGov
Environment International Government Ltd
A Service Disabled Veteran Owned Small Business

5505 34th Ave NE, Seattle, WA 98105
p. (206) 525-3362 f. (206) 525-0869

Laboratory
Sampler
Preservative
Bottle Type

Sample ID
Sample Location
Date
Time
Media
Analyses

EPA projects where the samples are to be transferred to a Contract Laboratory Program (CLP) laboratory, the sample labels must be generated using EPA's FORMS II Lite™ software prior to entering the field to sample. Other EPA projects may constitute the use of FORMS II Lite™ for tracking samples regardless of whether or not the samples will be submitted to a CLP laboratory. If this is the case, FORMS II Lite™ should be utilized to generate sample labels prior to sampling.

For all other projects, sample labels can either be generated prior to sample collection or handwritten in the field. All sample labels should contain the information below. Labels may contain other optional information such as assigned laboratory, analyses and bottle type.

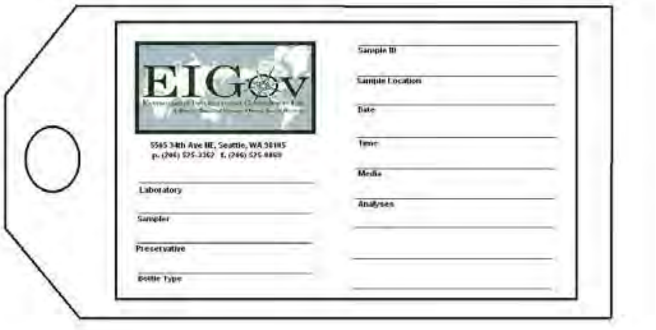
- Sample ID

- Sample location
- Preservation
- Samplers initials
- Date and time of collection
- Sample media

Hand-written labels completed prior to sample collection will contain all information except sampler initials, date, and time. It is the responsibility of the sampler to confirm that the information on the label is correct before collecting the sample. The sampler must initial and indicate the date and time of sample collection on pre-labeled containers. After providing the sample date, time and sampler initials, all labels should be additionally secured with clear tape to maintain legibility of the label.

Sometimes it may not be possible to apply a sample label directly to the sample container. An example of this is when pre-weighed VOA vials are used for collection of soil samples via EPA Method SW-846 5035A. Adding a label to the vial would add additional weight to the vial and skew sample results which requires proper determination of the weight of the soil added to the vial. In this case, a sample tag must be used. The sample label is applied to the sample tag and attached to the sample container with the tag string. The laboratory will be able to identify the sample and remove the tag temporarily to weigh the container. See Figure 4 for an example sample tag.

Figure 4: Sample Tag



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Laboratory

Sampler

Preservative

Bottle Type

Sample ID

Sample Location

Date

Time

Media

Analyses

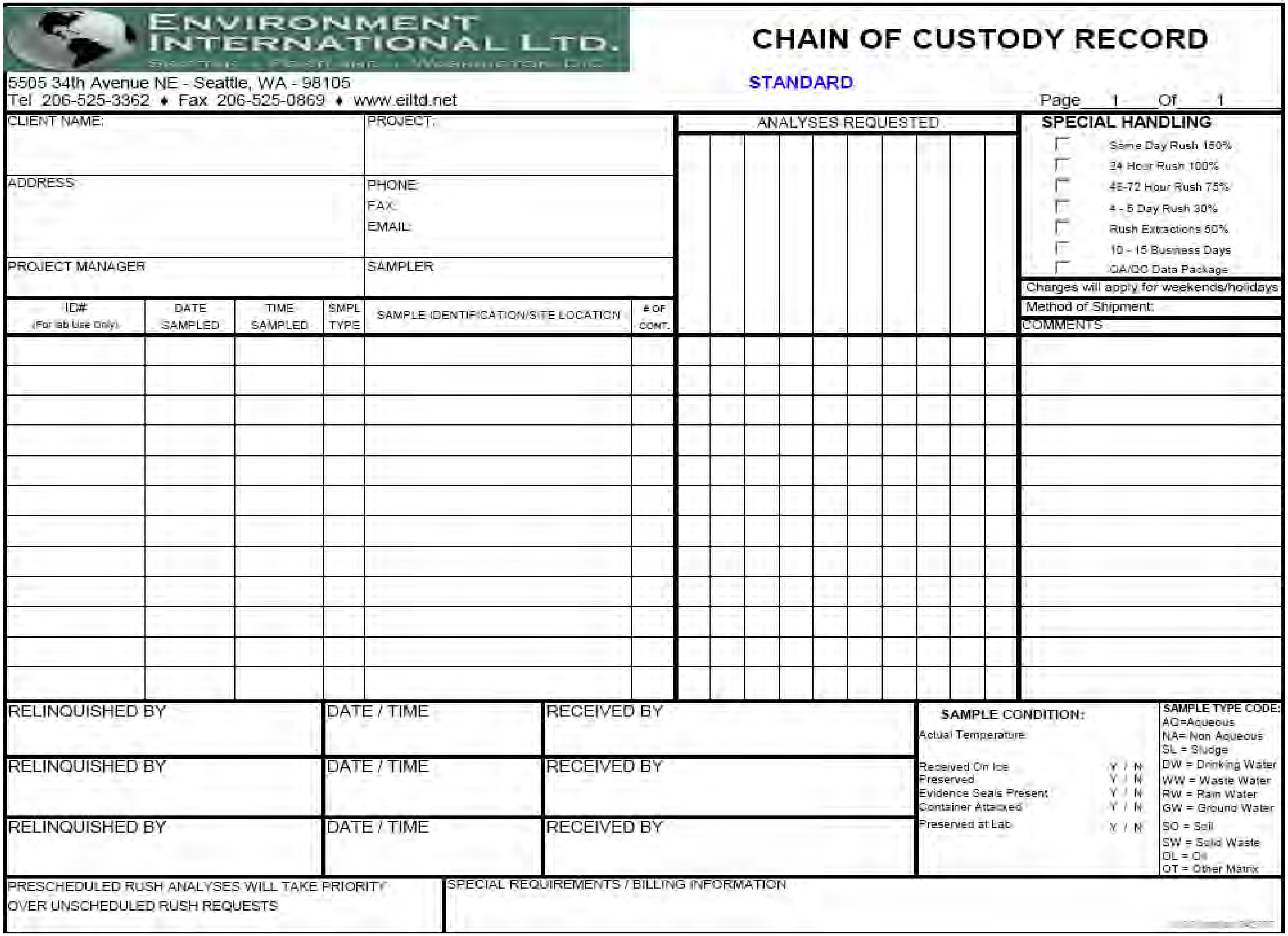
8. Documentation

The COC form may be provided by the laboratory or a generic EI COC may be used in its place. See Attachment 1 for a generic EI COC form.

9. Measure of Proficiency

Field staff will demonstrate proficiency by successfully completing Sections 7 and 8 a minimum of two times under the direct supervision of a Project Manager, Field Team Leader, Senior Associate or designee with appropriate field experience.

Example Chain-of-Custody Sheet



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CHAIN OF CUSTODY RECORD

STANDARD

Page 1 Of 1

CLIENT NAME:	PROJECT:
ADDRESS:	PHONE: FAX: EMAIL:
PROJECT MANAGER	SAMPLER

SPECIAL HANDLING

- ☐ Same Day Rush 150%
- ☐ 24 Hour Rush 100%
- ☐ 48-72 Hour Rush 75%
- ☐ 4 - 5 Day Rush 30%
- ☐ Rush Extractions 50%
- ☐ 10 - 15 Business Days
- ☐ QA/QC Data Package

Charges will apply for weekends/holidays

Method of Shipment:

ID# (For lab Use Only)	DATE SAMPLED	TIME SAMPLED	SMPL TYPE	SAMPLE IDENTIFICATION/SITE LOCATION	# OF CONT.	ANALYSES REQUESTED										COMMENTS

RELINQUISHED BY	DATE / TIME	RECEIVED BY
RELINQUISHED BY	DATE / TIME	RECEIVED BY
RELINQUISHED BY	DATE / TIME	RECEIVED BY

SAMPLE CONDITION:

Actual Temperature

Received On Ice	Y / N
Preserved	Y / N
Evidence Seals Present	Y / N
Container Attacked	Y / N
Preserved at Lab	Y / N

SAMPLE TYPE CODE:
AQ=Aqueous
NA= Non Aqueous
SL = Sludge
DW = Drinking Water
WW = Waste Water
RW = Rain Water
GW = Ground Water
SO = Soil
SW = Solid Waste
OL = Oil
OT = Other Matrix

PRESCHEDULED RUSH ANALYSES WILL TAKE PRIORITY OVER UNSCHEDULED RUSH REQUESTS

SPECIAL REQUIREMENTS / BILLING INFORMATION

QUALITY ASSURANCE/QUALITY CONTROL SAMPLE COLLECTION

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Suzanne Dolberg	Craig Christian	5/15/2009		

This Standard Operating Procedure (SOP) contains seven sections:

1. Purpose
2. Application
3. References
4. Associated SOPs
5. QA/QC Sample Types
6. QA/QC Sample Collection Procedures
7. Measure of Proficiency

1. Purpose

The purpose of this SOP is to provide field personnel with procedures for collecting quality assurance (QA) and quality control (QC) samples in water and soil matrices.

2. Application

The procedures in this SOP are applicable to the collection of QA/QC samples in water and soil matrices. Specific instructions for collecting other types of QC samples or QC samples of other matrices (e.g., fish tissue) will be addressed in the site- or project-specific Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP).

3. References

Consult the site-specific SAP or QAPP for modifications that may be necessary to these procedures.

4. Associated SOPs

EI-1010 Surface Soil Sampling

EI-1011 Groundwater Sampling

EI-4002 Standard Penetration Tests and Split-Spoon Sampling

EI-4025 Direct Push Soil and Groundwater Sampling

5. QA/QC Sample Types

The goal of including QA/QC samples with any sampling or analytical event is to be able to identify, measure, quantify, and control the sources of error that may impact results. QA/QC samples must be taken, prepared, and analyzed in the same manner as the environmental samples.

QC samples such as blanks, field replicates, and matrix spikes verify performance of the field and/or laboratory process to provide reliable information about the environmental condition being evaluated. QA samples such as performance evaluation (PE) samples are generally used to establish intra-laboratory or method performance precision and bias not associated with specific conditions being evaluated. Several types of samples may be used for establishing QA/QC. Sample types and their definitions and purpose are outlined in Table 1.

Three commonly encountered terms in QA/QC sample discussions are accuracy, bias, and precision.

- *Accuracy* is the closeness or agreement between an observed value and an accepted reference value.
- *Bias* is the deviation of a measured value from a reference value or a known spiked amount, and is determined by calculating percent recovery.
- *Precision* is the closeness or agreement among individual measurements

Table 1
QA/QC Sample Types

QA/QC Type	Definition	Purpose
Field Duplicate	An independent sample collected as close as possible to the same location and time and using the same procedures as the field sample. Field duplicate pairs are considered equally representative of the sampled area.	To evaluate the overall precision of the field and laboratory procedures including innate non-homogeneity of the sample matrix.
Split Sample	A sample collected by dividing a sample after any mixing or homogenization into two aliquots for independent analysis (generally by an independent laboratory).	To evaluate the precision of the analytical results.
Matrix Spike (MS)	A sample collected as a split sample (divided into multiple aliquots following homogenization) which is spiked with target analytes at the laboratory before analysis.	To evaluate analytical accuracy and bias of methods in site specific matrices.
Matrix Spike Duplicate (MSD)	A sample collected in conjunction with an MS as a second split sample which is spiked with target analytes at the laboratory before analysis.	To evaluate precision of the analytical procedures
Performance Evaluation (PE) Sample	A sample of known or well established concentration of target analytes provided to the laboratory for analysis, without information as to the analytes identity or concentration. (Note double blind PE samples are PE samples that are not identified as PE samples to any involved in the sampling or analysis process).	To evaluate laboratory accuracy with regard to identification and quantitation of analytes.

Table 1
QA/QC Sample Types

QA/QC Type	Definition	Purpose
Field Blank*	An aqueous sample collected on-site during sampling activities by using analyte-free water to prepare the sample in the field including pouring the sample under ambient field conditions and preserving the sample.	To check for cross-contamination during sample collection, preservation, shipment, and at the laboratory.
Equipment Blank (or Rinsate Blank)	An aqueous sample collected by rinsing decontaminated, non-dedicated sample equipment with analyte-free water prior to collection of subsequent samples .	To evaluate bias from potential carryover of target analytes from contaminated well samples to subsequent samples and the effectiveness of field decontamination procedures.
Trip Blank	A sample of analyte-free water transported with empty sample containers to the field, stored with sample containers, and returned unopened to the laboratory with collected samples. Trip blanks are used only for analysis of volatile organic target analytes (VOCs or VPH, etc.)	To evaluate bias from potential contamination during bottle and/or sample transport and storage.
Other blanks (storage blanks, bottle blanks, filter blanks, etc.)	Analyte free water used to more specifically identify sources of contamination. Typically these would only be employed where previous blanks indicate a history of contamination.	To evaluate bias from potential field sources
Temperature Blank	A bottle or vial filled with water and shipped to the laboratory with the samples for receipt temperature verification.	To check that samples are received at cool temperatures generally 4± 2°C .

*** Note:** In addition to the specific definition of the term “field blank”, this phrase is also used to describe collectively all types of blanks designed to evaluate potential bias introduced outside the laboratory including but not limited to field blanks, rinsate blanks, storage blanks, filter blanks, bottle blanks and trip blanks.

6. QA/QC Sample Collection Procedures

6.1 Field Duplicates

An independent sample collected as close as possible to the same location and time, and using the same procedures as the field sample. Field duplicate pairs are considered equally representative of the sampled area.

6.1.1 Water Samples

To ensure that field duplicate samples are equally representative of the sampled area at a given time, samplers should alternate fill field duplicate sampling containers for the same analysis. For example, in using a Kemmerer sampler to collect surface water samples, the sampler volume is typically inadequate to collect sufficient water for all containers. Field duplicate containers should be alternately filled for a single analysis from the same grab volume, as opposed to collection of multiple analysis sample containers for one sample followed by a second grab for the field duplicate sample containers. The same rationale applies to low flow sampling where sample and field duplicate sample containers must be alternatingly filled for each analysis rather than collection of all analyses for the sample followed by collection of the field duplicate. Sample containers for volatile analyses should always be collected at once to complete filling and sealing with no delay to allow possible volatilization.

6.1.2 Solid Samples

To ensure that solid samples are equally representative of the sampled area, samplers should collect soil and sediment samples as close as possible to the same location. Soils should be independently collected and independently homogenized (in the case of non-volatile analyses) such that there is adequate soil volume for all analyses. Soil sample field duplicates must represent native heterogeneity of the area sampled. True field duplicates are not split from an homogenized sample volume. However, in some cases, split samples may be appropriate for the project where the objective is to measure analytical precision as opposed to overall precision of the sampling and analysis processes.

6.2 Split Samples

Split samples are intended to evaluate analytical precision by splitting of individual sample volumes for separate analysis. With solid samples, splits are collected after homogenization to remove variability due to field sampling and native matrix heterogeneity. Often, split samples are provided to separate laboratories for independent analysis. However, even when split samples are provided to separate laboratories, the results cannot be used to evaluate accuracy unless there are additional lines of evidence (e.g., data validation) to suggest reliability of one laboratory result over the second.

6.3 Matrix Spike/Matrix Spike Duplicates

MS/MSDs are collected as a split sample (i.e., divided sample volumes into multiple aliquots following solids homogenization) which is spiked with target analytes at the laboratory before analysis for the purpose of evaluating analytical variability. The key aspect of MS/MSDs is that the sample containers must be as close to identical as possible. Water samples must be collected by alternately filling sample containers to best achieve the comparable samples in the native samples and MS/MSDs. Soil sample volumes must be homogenized prior to division into sample containers for the native sample and MS/MSD.

6.4 Performance Evaluation Samples

PE samples contain known or well established concentrations of target analytes in samples provided to the laboratory without information as to the analytes identity or concentration. Submitting a PE sample to a laboratory does not require the collection of a sample in the field. Unless stated otherwise in the site-specific SAP or QAPP, PE samples will be single blind PE samples, purchased from a third party, and shipped along with or in advance of field samples with the preparation instructions. PE samples may be vials requiring dilution or matrix materials such as soil or sand. Single blind PE samples may be identifiable as PE samples. Double blind PE samples are not identifiable as PE samples and may be part of a larger QA program and shipped as an independent sample lot for pre-qualification of a laboratory. Single blind PE samples, especially those requiring dilution in analyte free water, must be shipped to include instructions on preparation. The PE samples will be assigned sample identifiers as described in the site specific SAP or QAPP and included on the chain-of-custody. Lot number and third party provider information will not be supplied to the laboratory if the information can be used to obtain actual analysis results or acceptable limits.

6.5 Field Blanks

Field blanks are aqueous samples collected on site during sampling activities by using analyte-free water to prepare the sample in the field, including pouring the sample under ambient field conditions and preserving the sample. Field blanks are generally collected when only dedicated equipment is used for sample collection.

1. Before going out into the field, determine the appropriate type of analyte-free water that is needed by consulting the site-specific SAP. Generally, distilled water is used for field blanks for organic analyses and de-ionized water is used for field blanks for inorganic analyses; however, the type and source of water that can be used may vary based on the contaminants of concern on the site and the detection limits of the analyses. HPLC-Grade or pesticide-grade water may be required.
2. Collect the field blank by transferring the analyte-free water into a set of individual samples containers at the sample location immediately following collection of the field sample.

6.6 Equipment Rinsate Blanks

An equipment rinsate blank is an aqueous sample that is collected by rinsing decontaminated non-dedicated sample equipment with analyte-free water and collecting the rinsate into appropriately preserved containers.

1. Before going out into the field, determine the appropriate type of analyte-free water that is needed by consulting the site-specific SAP. Generally, distilled water is used for field blanks for organic analyses and deionized water is used for field blanks for inorganic analyses; however, the type and source of water that can be used may vary based on the contaminants of concern on the site and the detection limits of the analyses. HPLC-Grade or pesticide-grade water may be required.
2. In the field, after collecting a sample, decontaminate the associated sample equipment using the decontamination procedures established in the site-specific SAP. The water used in the equipment decontamination process is frequently not the same analyte-free water used for collection of the rinsate blank sample.
3. Pour the analyte-free water over the sample equipment collecting the runoff into a set of individual sample containers immediately after decontamination is complete. If several pieces of equipment have been used to collect the sample (e.g., stainless steel bowl and tools), the water will be poured over the decontaminated tools into the decontaminated sample vessel and the water poured from the vessel into the appropriate sample containers.

6.7 Trip Blanks

A trip blank is a sample container that has been filled with analyte-free water at the laboratory, transported to the field with the empty sample containers, remains unopened during the sampling event, and is transported back to the laboratory with the samples for analysis. Trip blanks are used when samples are collected for volatile analyses only (VOCs or VPH, etc). Submitting a trip blank to a laboratory does not require the collection of a sample in the field. The trip blank will be given a sample identifier as described in the site-specific SAP and included on the chain-of-custody.

6.8 Temperature Blanks

A temperature blank is a small bottle or vial that is filled with analyte-free water and shipped to the laboratory with the samples. A temperature blank must be included in each cooler alongside samples whenever sample temperature must be controlled and documented. Submitting a temperature blank to a laboratory does not require the collection of sample in the field. Temperature blanks are marked only as “Temperature Blank”, and no sample identifiers are assigned nor is the sample included on the chain-of-custody.

7. Measure of Proficiency

Field staff will demonstrate proficiency by successfully completing Sections 6.0 and 7.0 a minimum of two times under the direct supervision of a Project Manager, Field Team Leader, Senior Associate or designee with appropriate field experience.

FIELD EQUIPMENT DECONTAMINATION

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Suzanne Dolberg	Craig Christian	5/15/2009		

This Standard Operating Procedure (SOP) contains nine sections:

1. Purpose

The purpose of this SOP is to provide field personnel with a description of the methods used for preventing cross-contamination and general guidelines for selecting the proper decontamination procedures which are dependent on equipment type, contaminants of concern, and contaminant concentrations.

2. Application

This SOP should be used by field personnel responsible for the decontamination of field equipment including soil/sediment sampling tools, groundwater/surface water sampling equipment, heavy equipment, and field measurement equipment for site contaminants including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides/herbicides, polychlorinated biphenlys (PCBs), metals, and trace nitroaromatics.

3. References

Consult the site-specific Sampling and Analysis Plan (SAP) for modifications that may be necessary to these procedures and check with the site-specific Health and Safety Plan (HASP) to determine if additional personal protective equipment (PPE) is required.

4. Associated SOPs

EI-4033 Investigation Derived Waste Handling

5.0 Equipment

The actual equipment needed from the list below is dependent on the equipment and contaminant types.

- Nitrile gloves
- Any other PPE required per the HASP or SAP based on site hazards
- Polyethylene sheeting
- Utility knife
- Paper towels
- Plastic garbage bags
- Aluminum foil
- Plastic buckets and lids, 5-gallon
- Large plastic scrub brushes
- Bottle brushes or small wire brushes
- Squirt bottles
- Non-phosphate detergent (e.g., Liquinox)
- Approved potable water
- De-ionized or distilled water
- Reagent-grade nitric acid
- Pesticide-grade methanol or hexane or other, as specified by the SAP
- Pressurized sprayers or steam cleaners
- Drums or other suitable containers for holding waste decontamination fluids

6.0 Decontamination Summary

Removing or neutralizing contaminants from equipment minimizes sample cross-contamination and reduces the likelihood of transfer of contaminants to clean areas.

The first step in the decontamination process includes the removal of gross contamination using physical means. Physical decontamination procedures include scrubbing equipment with brushes or high pressure washing. Next, a soap and water wash followed by a rinse with approved water removes all visible particulate matter and oil or grease. Approved water may include store bought deionized or distilled water or potable water from a known source, as defined in the SAP. An acid rinse with 1% or 10% nitric acid may then be performed to remove trace inorganic contaminants followed by another rinse with approved water. Use 10% nitric acid for plastics and glass and 1% for metallic sampling equipment. If organic contaminants are a concern, an appropriate pesticide-grade solvent rinse is performed followed by another rinse with approved water. Common solvents used are methanol for VOCs and SVOCs or hexane for PCBs. Consult the SAP for the contaminants of concern on the site and the appropriate solvent for decontamination. The equipment is then allowed to air dry and a final rinse with approved water is performed. After decontamination is completed all liquid waste is considered investigation-derived waste and will be managed in accordance with EI4033.

The decontamination procedure described above may be summarized as follows:

1. Physical decontamination
2. Non-phosphate detergent wash
3. Approved water rinse
4. 1% or 10% Nitric acid
5. Approved water rinse
6. Solvent rinse
7. Rinse with approved water
8. Air dry
9. Rinse with approved water

If a particular contaminant fraction is not present or present at elevated concentrations based on site data, the procedure specified above may be modified for the site. For example, the nitric acid rinse may be eliminated if metals are not a concern, or the solvent rinse may be eliminated if organics are not of concern. If contaminant concentrations are very low Steps 4 through 7 may be eliminated completely resulting in the following five step procedure:

1. Physical decontamination
2. Non-phosphate detergent wash
3. Approved water rinse
4. Air dry
5. Rinse with approved water

7.0 Decontamination Procedures

7.1 Soil and Sediment Sampling Equipment

Soil and sediment sampling equipment may include items such as stainless steel bowls, trowels, scoops, and spoons. Equipment to be used during sampling will be decontaminated at a designated decontamination area. Decontaminated equipment will then be wrapped in aluminum foil with the shiny side facing out.

The following procedures will be followed for decontamination of soil and sediment field sampling equipment. If only organic contaminants are a concern Steps 7 and 8 below may be skipped; if only inorganic contaminants are a concern Steps 9 and 10 below may be skipped. For site locations with historical data indicating very low levels of contamination Steps 7 through 10 below may be eliminated.

1. Before commencing any decontamination activities, establish a decontamination area. The decontamination area will be set-up on a paved surface away from airborne sources of contamination, storm drains and other conduits whenever possible and the area covered with clean polyethylene sheeting. Alternatively, if paved areas are not available find a flat ground surface and cover with clean polyethylene sheeting. If the decontamination area must be set-up near storm drains or other conduits, the

decontamination area must be enclosed using containment berms.

2. Depending on the decontamination procedures for the particular contaminants of concern (see Section 6.0) set up enough plastic buckets on polyethylene sheeting to accommodate rinse water and solvents effectively creating decontamination "stations" for each step in the process moving from left to right. If particularly large pieces of sample equipment will need decontamination small children's' wading pools may be used in place of the buckets
3. Place the necessary decontamination tools, approved water, and solvents at each station. Solvents and acid rinses will be placed in appropriately labeled bottles. Don appropriate PPE as specified in the HASP.
4. Fill the initial "wash bucket" with approved water and non-phosphate detergent.
5. Submerge the sample equipment in the wash bucket and scrub all surfaces with a brush to remove all visible contamination. If equipment is heavily soiled, this procedure may need to be repeated using a fresh soap solution.
6. Rinse the equipment with approved water to remove all traces of soap, collecting the rinsate in a plastic bucket.
7. If inorganic contaminants are a concern, use a squirt bottle filled with nitric acid solution of the appropriate concentration (10% solution for plastic and glass or 1% solution or metallic equipment) to rinse the equipment, collecting the acid rinsate in a separate marked bucket. If inorganic contaminants are not a concern, skip to Step 9.
8. Rinse the equipment with approved water and collect the rinsate in a plastic bucket.
9. If organic contaminants are a concern, use a squirt bottle filled with an appropriate pesticide-grade solvent to rinse the equipment and collect the rinsate in a separate marked bucket. Never mix acid solution rinsates with solvent rinsate. If organic contaminants are not a concern, skip to Step 11.
10. Rinse the equipment with approved water and collect the rinsate in a plastic bucket.
11. Set the equipment out on clean polyethylene sheeting to air dry.
12. Perform a final rinse with approved water.
13. Wrap equipment in aluminum foil with the shiny side facing out.
14. Cover buckets with lids and manage in accordance with EI-4033.

7.2 Groundwater and Surface Water Sampling Equipment

Groundwater and surface water equipment may include items such as bailers, check values and tubing, submersible pumps, flow through cells, and bomb samplers,. Equipment used during sampling will be decontaminated at a designated decontamination area. Decontaminated equipment will then be placed in clean containers or enclosed in a clean plastic bag.

The following procedures will be followed for decontamination of groundwater and surface water field sampling equipment. If only organic contaminants are a concern Steps 5 and 6 below may be skipped; if only inorganic contaminants are a concern Steps 7 and 8 below may be skipped. For site locations with historical data indicating very low levels of contamination Steps 5 through 8 below may be eliminated.

1. Complete Steps 1 through 4 from Section 7.1
2. For bailers and other sample collection devices other than submersible pumps continue with Steps 5 through 12 from Section 7.1, placing fully decontaminated items in clean containers. If decontaminating a submersible pump, continue to Step 3 below.
3. For submersible pumps such as bladder pumps, remove the bladder assembly from the pump housing and submerge both portions in the wash bucket. Scrub the exterior housing with a stiff bristle brush. Manually compress and extend the bladder to pump the wash water thorough the assembly several times. For pumps that are not easily disassembled (such as electric submersible pumps), the pump may be setup in the same configuration as for sampling and a minimum of three pump assembly volumes pumped through.
4. Remove the pump parts from the wash bucket and submerge them in a bucket of clean approved water. Pour approved water over the pump housings. Submerge the bladder assembly and manually compress and extend the bladder to pump water through the assembly several times.
5. If inorganic contaminants are a concern, use a squirt bottle filled with 1% nitric acid and rinse the pump housing. Pour 1% nitric acid solution into the bladder and turn the bladder to rinse the entire interior of the bladder. Hold the pump intake over an acid solution waste bucket and carefully expel the solution by compressing the bladder. If the pump has only plastic parts a 10% nitric acid solution may be used.
6. Submerge the pump parts in a bucket of clean approved water. Pour approved water over the pump housing. Submerge the bladder assembly and manually compress and extend the bladder to pump water through the assembly several times.
7. If organic contaminants are a concern, use a squirt bottle filled with the appropriate pesticide-grade solvent to rinse the pump housing. Pour or squirt the appropriate solvent into the bladder and turn the bladder to rinse the entire interior of the bladder. Hold the pump intake over a solvent waste bucket and carefully expel the solution by compressing the bladder.
8. Submerge the pump parts in a bucket of clean approved water. Pour approved water over the pump housing. Submerge the bladder assembly and manually compress and extend the bladder to pump water through the assembly several times.
9. Set the equipment out on clean polyethylene sheeting to air dry.
10. Submerge the pump parts in a bucket of clean approved water. Pour approved water over the pump housing. Submerge the bladder assembly and manually compress and extend the bladder to pump water through the assembly several times.
11. Reassemble the pump and place in a clean container for transport to the next sample location.
12. Cover buckets with lids and manage in accordance with EI-4033.

7.3 Heavy Equipment Decontamination

Heavy equipment may include items such as drilling rigs and backhoes. All heavy equipment will be steam cleaned by the subcontractor before it is brought on site. The EI field team leader will inspect all heavy equipment for overall cleanliness and check for any leakage of petroleum, hydraulic, transmission fluids, or coolant. No equipment will be allowed on site until the source of the fluids has been identified, addressed, and the equipment properly cleaned.

Once on site, the actual drill rig or backhoe (deck and undercarriage) will not be steam cleaned between soil borings or test pits unless gross contamination is present. The subsurface drilling equipment including drill rods, augers, bits and tools will be decontaminated at a central decontamination area using the following procedures:

1. Remove gross contamination using a shovel or brush.
2. Transport the rig and tools to the decontamination area.
3. If the equipment is heavily soiled, use a brush with approved water and non-phosphate detergent to scrub the equipment. Steam clean drilling tools using approved water to rinse the soap solution off.
4. Steam clean all downhole drilling tools with approved water.
5. Allow equipment to air dry.
6. Mobilize to the next sample location in a manner that eliminates contact with contaminated media. In certain situations, it may be necessary to wrap tools in clean polyethylene sheeting for transport.
7. Containerize all fluids and manage in accordance with EI-4033.

7.4 Field Measurement Equipment

Water level indicators and downhole probes for measurement of water in wells and surface water bodies will be decontaminated between use by spraying with approved water and wiping with clean paper towels. If high levels of contaminants are present or the equipment comes into contact with non-aqueous phase liquid (NAPL), full decontamination procedures described in Section 7.2 should be followed.

8. Documentation

Decontamination procedures will be documented in the field log book according to EI4014. Documentation will include the procedures and liquids used in the decontamination process, and the disposition of the waste liquids.

9. Measure of Proficiency

Field staff will demonstrate proficiency by successfully completing the appropriate portions of Sections 7.0 and 8.0 a minimum of two times under the direct supervision of a Senior Associate with appropriate field experience or their designee.

ENVIRONMENTAL SAMPLE PACKAGING AND SHIPPING

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Suzanne Dolberg	Craig Christian	3/4/2010		

This Standard Operating Procedure (SOP) contains nine sections:

1. Purpose
2. Application
3. References
4. Associated SOPs
5. Equipment
6. Decontamination
7. Sample Packaging and Shipping Procedures
8. Documentation
9. Measure of Proficiency

1. Purpose

The purpose of this SOP is to provide field personnel with procedures for packaging and shipping environmental samples in a manner that will ensure the samples integrity.

2. Application

The procedures in this SOP will be followed when packing and/or shipping environmental samples for commercial or contract laboratory program routine analytical services laboratories. These procedures do not address international shipping, samples that exceed hazardous materials concentrations or volumes, samples meeting the definition of IATA Dangerous Goods, shipment of materials for disposal or any purposes except analysis, infectious substances such as untreated POTW wastewater or sludge, or shipping of samples on dry ice. The procedures described in this SOP are performed after environmental samples have been collected and placed in proper containers and correctly preserved according to the site- or project-specific Sampling and Analysis Plan (SAP) and in conformance with the site specific Health and Safety Plan (HASP).

3. References

Consult the site-specific SAP for modifications that may be necessary to these procedures and check with the site-specific HASP to determine if additional personal protective equipment (PPE) is required. Packaging and shipping of samples to Contract Laboratory Program (CLP) Routine Analytical Services (RAS) laboratories must comply with this procedure and requirements specified in the Contract Laboratory Program Guidance for Field Samplers, OSWER 9240.0-44, EPA 540-R-07-06, FINAL July 2007.

4. Associated SOPs

EI-1017 Chain-of-Custody and Sample Labeling

5. Equipment

- Gloves (generally Nitrile but other materials may be acceptable based on SAP or HASP requirements)
- PPE required per the HASP or SAP based on site specific hazards
- Chain-of-custody (COC) forms
- COC seals
- Coolers/Sample Shipment Containers
- Temperature blanks
- Large heavy duty plastic bags (e.g., trash bags)
- Plastic re-sealable bags in various sizes
- Ice (cubed or pelleted)
- Bubble wrap
- Strapping tape
- Clear shipping tape
- Paper towels
- Air bills, tags, cable ties
- Ball point pen
- Fine point permanent marker

6. Decontamination

In the event of sample spillage, decontamination procedures will be followed in accordance with EI-1008.

7. Sample Packaging and Shipping Procedures

Sample packaging and shipping requirements for laboratories contracted through the Contract Laboratory Program (CLP) for Routine Analytical Services (RAS) are specified by the contract requirements. If using a standard commercial laboratory please follow the packaging instructions in Section 7.1.1 below and the shipping instructions in Section 7.2.1. If using a CLP RAS laboratory, follow the instructions in Section 7.1.2 and 7.2.2.

Generally prior to packaging samples in coolers or other sample shipment containers for overnight shipment, all samples should be maintained at a cool temperature generally either refrigerated or in holding coolers. Samples maintained at ambient temperature retain enough heat to melt ice during shipping ensuring that samples will be received outside generally accepted temperature ranges. Samples may not require cooling prior to packaging during cold ambient weather but samplers must then ensure that samples are buffered from freezing temperatures that can cause expansion breakage of sample containers.

7.1 Sample Packaging

7.1.1 Sample Packaging – Commercial Laboratory

Environmental samples will be packaged in the following manner:

1. Choose a clean, sturdy cooler that is in good condition. Avoid using coolers that have molded handles if samples are to be shipped, as the air bill tag will need to be looped through the cooler handle.
2. Seal all drain holes inside and out with strapping tape to prevent leakage.
3. Check that all samples are tightly sealed and will not leak.
4. Check that the sample labels or tags have been properly filled out and match the COC. If water resistant labels have not been used apply clear shipping tape over the label.
5. Place wet ice into large re-sealable plastic bags. Do not use only the bags the ice was purchased in. Do not overfill the bags or fill bags with large solid chunks of ice. The samples will be less likely to break if the ice can move freely within the bag. Note: A five pound bag of ice can be emptied into a 2 or 2 ½ gallon re-sealable plastic bag with enough space to allow the ice to move freely.
6. Line the cooler with a large heavy duty plastic bag.
7. Place bagged ice on the cooler floor within the plastic bag creating a single layer.
8. Place at least two layers of bubble wrap over the layer of bagged ice.
9. Wrap glass or other fragile containers in bubble wrap. Glass VOA vials and other small breakable containers will also be placed in resealable plastic bags, one sample ID and analysis per bag.
10. Place containers in the cooler in an upright position. If large glass containers (e.g., 1L bottles or larger) are included in the shipment, extra bubble wrap should be placed in between the bottles for additional protection against breakage. Alternatively, bottles may be wrapped in an additional layer of bubble wrap in Step 9.
11. Place a temperature blank in the cooler alongside the samples.
12. Fill any empty space around the sides of the cooler with bubble wrap.
13. Place at least two layers of bubble wrap on top of the samples.
14. Place a single layer of bagged ice on top of the bubble wrap. If there is no room for a layer of ice at the top, the samples should be reconfigured in the cooler to allow bagged ice to be placed in the middle of the cooler amongst the sample containers.
15. Tie the large plastic bag closed, removing as much air as possible. If any empty space remains in the cooler fill with bubble wrap.
16. Complete the COC per ICF-1017.
17. Enclose the COC in a plastic re-sealable bag and tape the bag to the inside top of the

cooler and close the lid.

18. Wrap each end of the cooler with at least three layers of strapping tape. If the samples are being picked up by a courier do not seal the cooler. The courier will need to sign the COC upon receipt of samples. If shipping the samples proceed to the instructions in Section 7.2

7.1.2 Sample Packaging – CLP RAS Laboratories

Environmental samples for analysis under the CLP RAS program will be packaged in the following manner. Note that shipment of samples for CLP RAS analysis preserved with methanol according to SW 846 Method 5035A require specific dangerous goods shipping not covered by this SOP.

1. Choose a clean, sturdy cooler that is in good condition. Avoid using coolers that have molded handles if samples are to be shipped, as the air bill tag will need to be looped through the cooler handle.
2. Seal all drain holes inside and out with strapping tape to prevent leakage.
3. Fully chill all samples to 4 degrees C (+/- 2 degrees C).
4. Check that all samples are tightly sealed and will not leak and that COC seals have been affixed to each container such that the seal will break if the container is tampered with. Note: Pre-weighed sample vials for volatiles analysis should be placed in a plastic bag and the COC seal affixed over the bag seal. Never place COC seals or other labels directly on pre-weighed vials.
5. Check that the sample labels or tags have been properly filled out and match the COC and that the site name does not appear anywhere on sample documentation. If water resistant labels have not been used apply clear shipping tape over the label.
6. Seal all samples individually within clear plastic bags.
7. Double-bag wet ice into large re-sealable plastic bags. Do not overfill the bags or fill bags with large solid chunks of ice. The samples will be less likely to break if the ice can move freely within the bag. Note: A five pound bag of ice can be emptied into a 2 or 2 ½ gallon re-sealable plastic bag with enough space to allow the ice to move freely.
8. Line the cooler with clean, absorbent, non-combustible packing material (i.e., vermiculite).
9. Place a large heavy duty plastic bag in the cooler and atop the vermiculite.
10. Place bagged ice on the cooler floor within the plastic bag creating a single layer.
11. Place at least two layers of bubble wrap over the layer of bagged ice.
12. Wrap glass or other fragile containers in bubble wrap.
13. Place containers in the cooler in an upright position. If large glass containers (e.g., 1L bottles) are included in the shipment, extra bubble wrap should be placed in between the bottles for additional protection against breakage. Alternatively, bottles may be wrapped in an additional layer of bubble wrap in Step 9.
14. Place a temperature blank in the cooler alongside the samples.

15. Fill any empty space around the sides of the cooler with bubble wrap.
16. Place at least two layers of bubble wrap on top of the samples.
17. Place a single layer of double-bagged ice on top of the bubble wrap. If there is no room for a layer of ice at the top, the samples should be reconfigured in the cooler to allow bagged ice to be placed in the middle of the cooler amongst the sample containers.
18. Tie the large plastic bag closed, removing as much air as possible. If any empty space remains in the cooler fill with bubble wrap.
19. Complete the Tracking Report/Chain-of-Custody (TR/COC).
20. Enclose the TR/COC in a plastic re-sealable bag and tape the bag to the inside top of the cooler and close the lid.
21. Wrap each end of the cooler with at least three layers of strapping tape.

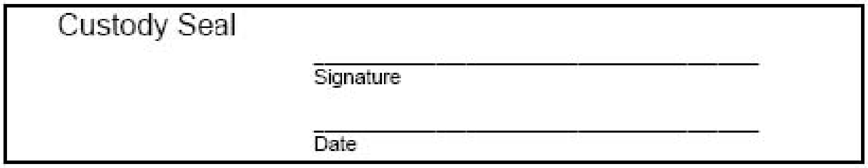
7.2 Sample Shipping

7.2.1 Sample Shipping – Commercial Laboratory

The following procedures will be followed when shipping environmental samples:

1. Sign and date two COC seals (Figure 1) and place them on opposite sides of the cooler opening in such a manner that the container cannot be opened without breaking the seals (See Figure 2).
2. Place a single layer of clear shipping tape over each seal.

Figure 1 Chain-of-Custody Seal

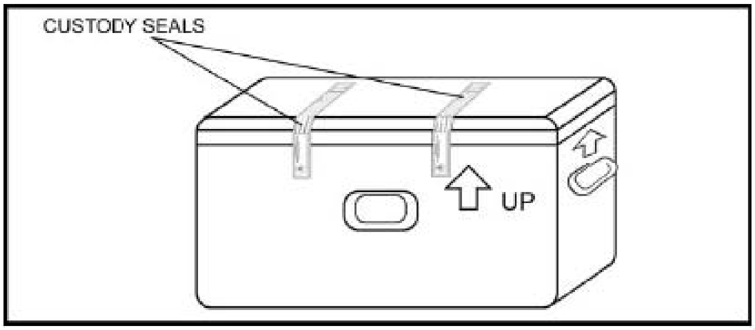


Custody Seal

____
Signature

____
Date

Figure 2 Chain-of-Custody Seal Proper Placement



3. If shipping samples through a shipping firm (e.g., Federal Express) fill out an air bill (see example in Attachment 1). Note that depending on the shipper multiple shipping containers/coolers may be shipped under the same air bill by marking the coolers for example “1 of 3”. The air bill must include all of the following information:
    - ***Section 1***: Fill in the date, your name, and the ICF office address, phone number, and FedEx account number.
    - ***Section 2***: Enter the project number as the internal billing reference.
    - ***Section 3***: Fill in the laboratory address and phone number; use “Sample Receiving” as the recipient (don’t use a specific name).
    - ***Section 4***: Check “FedEx Priority Overnight” checkbox.
    - ***Section 5***: Check “Other” checkbox.
    - ***Section 6***: Check “No” checkbox for dangerous goods[1].
    - ***Section 6***: Check “Saturday Delivery” checkbox, if necessary.
    - ***Section 7***: Check “Sender” checkbox

4. Peel the adhesive backing off the air bill and place on a plastic FedEx tag
5. Loop the end of the tag through one of the handles of the cooler and use the adhesive strip to secure. Insert a cable tie through the hole in the tag and secure around the cooler handle
6. Bring to the nearest FedEx facility
7. Retain the top copy of the air bill for tracking and billing purposes
8. Contact the project chemist to coordinate receipt with the laboratory or contact the laboratory directly to inform them of sample shipment.

7.2.2 Sample Shipping – CLP RAS Laboratory

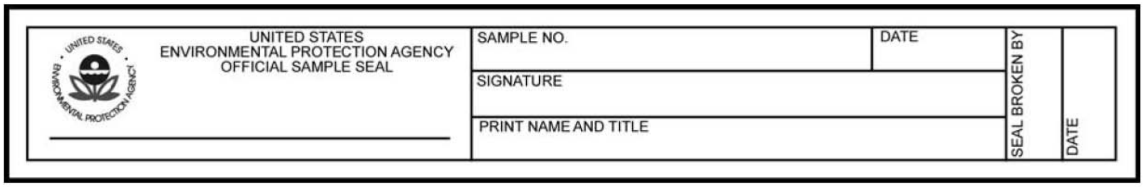
The following procedures will be followed when shipping environmental samples:

---

[1] Normally, samples are not considered dangerous goods. However, if you are submitting a sample consisting entirely of a hazardous material, then the sample must be shipped as hazardous materials. Shipping hazardous materials goes beyond what is specified in this SOP. Consult the H&S Coordinator for how to proceed in this situation.

1. Fill out 4 EPA COC seals (Figure 3). Make sure to both print and sign you name and include the date. Place one on each side of the cooler spanning the seal between the lid and bottom of the cooler in such a manner that the container cannot be opened without breaking the seals.
2. Place a single layer of clear shipping tape over each seal.

Figure 3 Chain-of-Custody Seal



UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
OFFICIAL SAMPLE SEAL

SAMPLE NO.	DATE	SEAL BROKEN BY
SIGNATURE		DATE
PRINT NAME AND TITLE		

3. Fill out a Federal Express air bill (see example in Attachment 1). Note that depending on the shipper multiple shipping containers/coolers may be shipped under the same air bill by marking the coolers for example “1 of 3”. If shipping via a different carrier or method consult the SAP for proper instructions. The FedEx air bill must include all of the following information:

- ***Section 1***: Fill in the date, your name, and the ICF office address, phone number, and FedEx account number.
- ***Section 2***: Enter the project number as the internal billing reference.
- ***Section 3***: Fill in the laboratory address and phone number; use “Sample Receiving” as the recipient (don’t use a specific name).
- ***Section 4***: Check “FedEx Priority Overnight” checkbox.
- ***Section 5***: Check “Other” checkbox.
- ***Section 6***: Check “No” checkbox for dangerous goods.
- ***Section 6***: Check “Saturday Delivery” checkbox, if necessary.
- ***Section 7***: Check “Sender” checkbox.

4. Peel the adhesive backing off the air bill and place on a plastic FedEx tag
5. Loop the end of the tag through one of the handles of the cooler and use the adhesive strip to secure. Insert a cable tie through the hole in the tag and secure around the cooler handle
6. Bring to the nearest FedEx facility
7. Retain the top copy of the air bill for tracking and billing purposes
8. Immediately contact the project chemist to coordinate with the CLP Regional RSCC or SMO designee. Never contact the CLP RAS laboratory directly. For each shipment by 8 AM the next day, the project chemist must provide the following information to the RSCC (or their designee) or to SMO:

- Contact name and phone number;
- SMO-assigned Case Number;
- Number, concentration, matrix and analysis of samples being shipped;
- Name of laboratory (or laboratories) to which the samples were shipped;
- Air bill number(s);
- Date of shipment;
- Case status (i.e., whether or not the Case is complete);
- Problems encountered, special comments, or any unanticipated issues;
- When to expect the next anticipated shipment; and
- An electronic export of the TR/COC Record

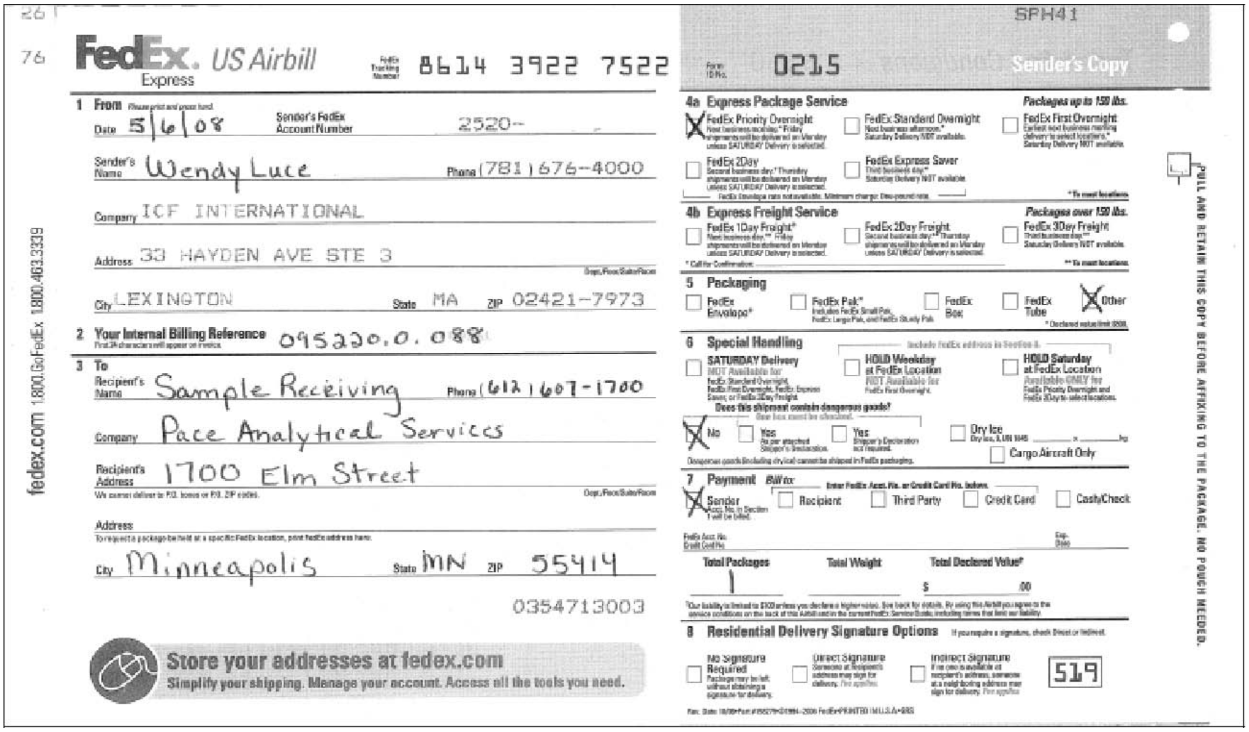
8. Documentation

If shipping samples, an air bill must be completed as described in Section 7.2. Procedures for filling out COC forms, COC seals, and sample labels and tags are included in ICF-1017.

9. Measure of Proficiency

Field personnel will demonstrate proficiency by successfully completing Sections 7.0 and 8.0 a minimum of two times under the direct supervision of a Project Manager, Field Team Leader, Senior Associate or designee with appropriate field experience.

Attachment 1 Example Completed Federal Express Air Bill



26
76

FedEx. Express US Airbill

FedEx Tracking Number 8614 3922 7522

Form ID No. 0215

SPH41

Sender's Copy

fedex.com 1.800.GoFedEx 1.800.463.3339

1 From Please print and press hard.
Date 5/6/08
Sender's FedEx Account Number 2520-
Sender's Name Wendy Luce
Phone (781) 676-4000
Company ICF INTERNATIONAL
Address 33 HAYDEN AVE STE 3
Dept./Floor/Suite/Room
City LEXINGTON State MA ZIP 02421-7973

2 Your Internal Billing Reference 095220.0.088
First 24 characters will appear on invoice.

3 To
Recipient's Name Sample Receiving
Phone (612) 607-1700
Company Pace Analytical Services
Recipient's Address 1700 Elm Street
We cannot deliver to P.O. boxes or P.O. ZIP codes.
Dept./Floor/Suite/Room
Address
To request a package be held at a specific FedEx location, print FedEx address here.
City Minneapolis State MN ZIP 55414

0354713003

Store your addresses at fedex.com
Simplify your shipping. Manage your account. Access all the tools you need.

4a Express Package Service
Packages up to 150 lbs.
☒ FedEx Priority Overnight
☐ FedEx Standard Overnight
☐ FedEx First Overnight
☐ FedEx 2Day
☐ FedEx Express Saver
FedEx Envelope rate not available. Minimum charge: One-pound rate.
* To most locations.

4b Express Freight Service
Packages over 150 lbs.
☐ FedEx 1Day Freight*
☐ FedEx 2Day Freight
☐ FedEx 3Day Freight
* Call for Confirmation:
** To most locations.

5 Packaging
☐ FedEx Envelope*
☐ FedEx Pak*
Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak.
☐ FedEx Box
☐ FedEx Tube
☒ Other
* Declared value limit $500.

6 Special Handling
Include FedEx address in Section 3.
☐ SATURDAY Delivery
NOT Available for FedEx Standard Overnight, FedEx First Overnight, FedEx Express Saver, or FedEx 3Day Freight.
☐ HOLD Weekday at FedEx Location
NOT Available for FedEx First Overnight.
☐ HOLD Saturday at FedEx Location
Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations.

Does this shipment contain dangerous goods?
One box must be checked.
☒ No
☐ Yes As per attached Shipper's Declaration.
☐ Yes Shipper's Declaration not required.
☐ Dry Ice Dry Ice, 9, UN 1845 ____ x ____ kg
☐ Cargo Aircraft Only
Dangerous goods (including dry ice) cannot be shipped in FedEx packaging.

7 Payment Bill to:
Enter FedEx Acct. No. or Credit Card No. below.
☒ Sender Acct. No. in Section 1 will be billed.
☐ Recipient
☐ Third Party
☐ Credit Card
☐ Cash/Check
FedEx Acct. No. Credit Card No.
Exp. Date

Total Packages 1
Total Weight
Total Declared Value† $ .00

8 Residential Delivery Signature Options
If you require a signature, check Direct or Indirect.
☐ No Signature Required
Package may be left without obtaining a signature for delivery.
☐ Direct Signature
Someone at recipient's address may sign for delivery. Fee applies.
☐ Indirect Signature
If no one is available at recipient's address, someone at a neighboring address may sign for delivery. Fee applies.

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PULL AND RETAIN THIS COPY BEFORE AFFIXING TO THE PACKAGE. NO POUCH NEEDED.

FIELD DOCUMENTATION AND FORMS

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Suzanne Dolberg	Craig Christian	5/15/2009		

This Standard Operating Procedure (SOP) contains seven sections:

1. Purpose
2. Application
3. References
4. Associated SOPs
5. Equipment
6. Field Documentation Procedures
7. Measure of Proficiency

1. Purpose

The purpose of this SOP is to establish a consistent method and format for the use and control of documentation generated during daily field activities. Field notes and forms are intended to provide sufficient information that can be used to recreate the field activities without needing to rely on memory. Field notes are the formal and permanent documentation of field activities and are therefore vitally important to the quality assurance program.

2. Application

The procedures in this SOP will be used during all field activities unless otherwise stated in the Sampling and Analysis Plan (SAP). These activities may include, but are not limited to, sampling activities, well installation and development, site reconnaissance, hydrologic and geotechnical testing, remediation, waste handling, utility clearance, and sample location surveying. Note that some projects may require agency or contract specific forms for documentation.

3. References

Consult the site-specific SAP for modifications that may be necessary to these procedures and check with the site-specific Health and Safety Plan (HASP) to determine if additional personal protective equipment (PPE) is required.

4. Associated SOPs

ICF-1010 Surface Soil Sampling

ICF-1011 Groundwater Sampling

ICF-4000 Exploratory Pits and Trenches

ICF-4001 Exploratory Boring procedures

ICF-4002 Standard Penetration Tests and Split-Spoon Sampling

ICF-4008 Monitoring Well Installation

ICF-4010 Monitoring Well Development

ICF-4012 Monitoring Well Water Level Measurement

ICF-4025 Direct Push Soil and Groundwater Sampling

ICF-4033 Investigation Derived Waste Handling

ICF-5204 Field Screening Equipment Calibration

5. Equipment

- Log books –bound with consecutively numbered pages
- Black or blue ballpoint pens
- Black or blue fine tip permanent markers
- Field forms

6. Field Documentation Procedures

6.1 Site and Field Log Books

Site and field logbooks provide a daily handwritten account of all field activities. Logbooks will be permanently bound and have consecutively numbered pages. All entries will be made in blue or black ink and corrections will be crossed out using a single line and the individuals' initials and the date. Entries will be made in a legible handwriting. Each page of the logbook will be signed and dated by the person completing the log. No blank lines will be left between entries. Partially completed pages will have a slanted line drawn through the unused portion at the end of each day.

The cover of each logbook will include the facility name, the name of the subcontractor or agency completing the logbook, and the date the logbook was started. The site logbook will be a record of all site activities completed for each day of operation by the field team leader. The field logbook will be a record of field activities that are entered in real time by field personnel. Based on the number of separate field activities conducted, there may be several field logbooks but there will only be one site logbook.

6.1.1 Site Logbooks

The site logbook will be filled out by the field team leader and will contain the following information for each day on site at a minimum:

- List of all field logbooks created for the project
- Date
- Names, titles, and organizational affiliations of all project-related personnel and site visitors

- Weather conditions
- Activities conducted
- Any changes made to the established project procedures
- Problems encountered during the day and project impacts

6.1.2 Field Logbooks

The field logbook(s) will be filled out by field personnel and will contain the following information at a minimum:

- Date and time of each entry
- Names, titles, and organizational affiliations of all personnel performing the task
- Chronological description of field observations, significant conversations and events
- Level of safety protection
- Samples collected: including sample location, sample IDs, and any quality control samples collected including rinsate blank collection procedures and water used
- Equipment names and serial numbers, calibration and maintenance
- Sampling equipment decontamination
- Waste handling activities
- Problems encountered during the day and project impacts
- Deviations from approved procedures or work plans and the rationale for the change
- Photos taken along with the photo number and a description

6.2 Field Forms

Additional field forms may be required for each specific field activity. The use of field forms is described in the SOP for each specific activity. Field Forms for a variety of field activities are included in an attachment to this SOP:

- Soil Boring Log
- Sediment Coring Log
- Surface Soil Sampling Log
- Test Pit Excavation Profile
- Small Diameter Well Form
- Monitoring Well Construction Form (Stick Up)
- Monitoring Well Construction Form (Flush Mount)
- Monitoring Well Development Form
- Monitoring Well Water Level Form
- Groundwater Low Flow Sampling Sheet

- Monitoring Well Sampling Sheet (Volume-Based)
- Field Instrument Calibration Record
- Investigation Derived Waste Log
- Daily Drilling Report

7. Measure of Proficiency

Field staff will demonstrate proficiency by successfully completing Section 6.0 a minimum of two times under the direct supervision of, and acceptance by, a Senior Associate with appropriate field experience or their designee.

INVESTIGATION-DERIVED WASTE HANDLING

Written By:	**Approved By:**	**Date:**	**QA Concurrence:**	**Date:**
Suzanne Dolberg	Craig Christian			

This Standard Operating Procedure (SOP) contains nine sections:

1. Purpose
2. Application
3. References
4. Associated SOPs
5. Equipment
6. Decontamination
7. IDW Procedures
8. Documentation
9. Measure of Proficiency

1. Purpose

The purpose of this SOP is to provide procedures to field personnel for handling investigation-derived waste (IDW) generated during site activities.

2. Application

All IDW must be handled and disposed of in accordance with all applicable federal, state, and local regulations. IDW that is determined to be non-hazardous may be able to be disposed of on site in accordance with the site-specific Sampling and Analysis Plan (SAP). All IDW should be handled as potentially hazardous until it can be documented otherwise. This SOP is intended to provide procedures for handling, labeling, storing, and documenting IDW that will be containerized for off-site disposal. This SOP does not cover waste characterization or actual disposal, which will be documented in the SAP.

Three basic types of waste may be generated during field work in the following forms:

- *Aqueous*: decontamination and drilling fluids, groundwater generated from well development and well purging, etc.
- *Solid*: drill cuttings, excess soil sample material, concrete, etc.
- *PPE/Disposable Equipment*: spent personal protective equipment (PPE), paper towels, sample tubing, filters, etc.

3. References

Consult the site-specific SAP for modifications that may be necessary to these procedures and check with the site-specific Health and Safety Plan (HASP) to determine if additional PPE is required.

USEPA, 1991. *Management of Investigation-Derived Wastes during Site Inspections*. EPA/540/G-91/009.

4. Associated SOPs

EI-1008 Field Equipment Decontamination

5. Equipment

- Nitrile gloves
- Steel-toed boots
- Any other PPE required per the HASP or SAP based on site hazards
- Handheld photoionization detector (PID)
- DOT-approved drums
- Drum lids, rings, gaskets, and fasteners/bolts (for soil and solids)
- Drum liners (for soil and solids)
- Socket wrench for drum ring bolts (usually 5/8 inch)
- Drum bung wrench
- Plastic 5-gallon buckets and lids
- Funnels, as needed
- Heavy-duty (10-mil) polyethylene sheeting, as needed
- Containment berms, as needed
- *Documentation*: Investigation Derived Waste Log (Attachment 1) and IDW labels (Attachment 2)

6. Decontamination

All non-disposable equipment that is used in the handling and management of IDW will be decontaminated prior to arrival on site, between sampling locations, and before leaving the site. Decontamination procedures will be followed in accordance with EI-1008.

7. IDW Procedures

1. Establish a secure drum storage area before commencing site activities. Drums should be stored on a paved surface away from storm drains and other conduits. Alternatively,

if paved areas are not available place drums on a flat surface covered with or heavy duty polyethylene sheeting. If IDW must be stored near storm drains or other conduits, the storage area must be enclosed using containment berms. Drums should be placed on pallets to facilitate transport and so they do not sink into or freeze to the ground.

2. Inspect drums to make sure they are in good condition and that all lids, rings, gaskets, fasteners/bolts, and liners are present.
3. All soil, aqueous, and solid waste (trash) will be drummed separately. Soil and solid waste will be drummed in open-top DOT-approved drums with drum liners. Aqueous waste will be drummed in close-top DOT approved drums with a bung.
4. All drums must be labeled with an IDW label from the moment any waste is placed in the drum. The label shall be placed on the side of the drum, not the top. Use a permanent marker to fill in the information on the label. The IDW label must contain the following items:
    - Site name
    - Point of contact and phone number
    - Waste sample locations
    - Type of waste
    - Potential contaminants
    - Accumulation start date
    - Drum ID (see Step 5)
5. The drum ID will be assigned based on the type of waste generated, the drum number, and the month and year generated:
    - e.g. AW-01-0408
        - Type of waste (AW = Aqueous Waste, SW = Soil Waste, TW = Trash Waste)
        - Drum number - number drums consecutively (01, 02, 03, 04, etc.)
        - Date (MMYY) – at start of generation (0408 for April 2008)
6. Record each drum on the Investigation-Derived Waste Log if multiple drums will be generated during the field program.
7. Drums that have been filled or partially filled drums that are not currently being used should be moved back to the secure drum storage area.
8. Store drums in rows no larger than 2 drums deep with labels facing outward for identification purposes. ***Never stack drums!***
9. Refer to the site-specific SAP for IDW sample analysis and disposal procedures.

8. Documentation

An Investigation-Derived Waste Log for each sampling program and Investigation-Derived Waste Labels for each drum of waste produced must be completed. See Attachments 1 and 2. Field notes should specify the number of drums and contents generated each day.

9. Measure of Proficiency

Field staff will demonstrate proficiency by successfully completing Sections 7.0 and 8.0 a minimum of two times under the direct supervision of a Senior Associate with appropriate field experience or their designee.

Attachment 1 Investigation Derived Waste Log

Investigation-Derived Waste Log

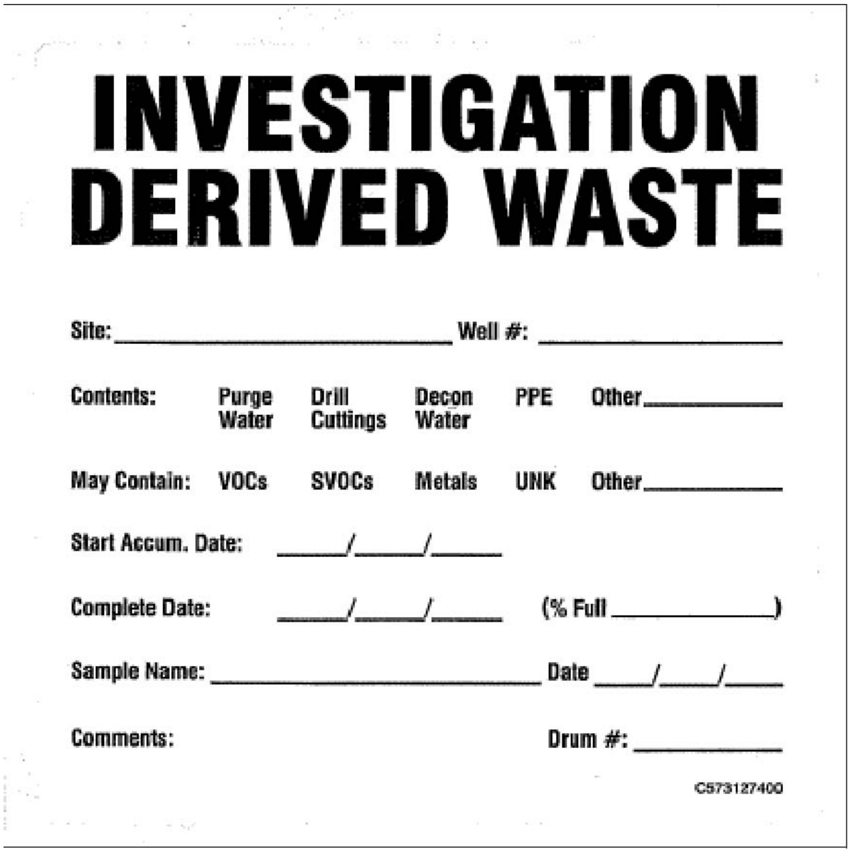
Client:
Project:
Project No.:
Date:

Drum No.	**Waste Type**	**Drum Type**	**Drum Size (gal)**	**Drum Condition**	**Start Date**	**End Date**	**Approximate Volume**
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E
	AW / SW / PW	SS / PE	55 /	G / F / P			F / 75% / 50% / 25% / E

Notes:

Signature:
Date:
Printed Name:
Position:

Attachment 2 Investigation Derived Waste Label



INVESTIGATION DERIVED WASTE

Site: ______________________ **Well #:** ______________

Contents:	Purge Water	Drill Cuttings	Decon Water	PPE	Other ________
May Contain:	VOCs	SVOCs	Metals	UNK	Other ________

Start Accum. Date: ____/____/____

Complete Date: ____/____/____ (% Full ________)

Sample Name: ______________________ **Date** ___/___/___

Comments: **Drum #:** ________

C573127400

FIELD SCREENING EQUIPMENT CALIBRATION

Written By:	Approved By:	Date:	QA Concurrence:	Date:
Suzanne Dolberg	Craig Christian	3/4/2010		

This Standard Operating Procedure (SOP) contains nine sections:

1. Purpose
2. Application
3. References
4. Associated SOPs
5. Equipment
6. Decontamination
7. Calibration Procedures
8. Documentation
9. Measure of Proficiency

1. Purpose

The purpose of this SOP is to provide procedures to field personnel responsible for the calibration of field screening equipment. This SOP covers the most commonly used screening instruments and is not intended to be all-inclusive. Consult the manufacturer's operations manual or the site-specific Sampling and Analysis Plan (SAP) for equipment not covered by this SOP.

2. Application

This SOP is intended for use by field personnel operating any of the following field screening equipment:

- Photovac® 2020 or 2020PRO Plus Photoionization Detector (PID)
- MiniRAE® 2000 PID
- YSI® 6-Series Multi-parameter Probes [pH, temperature, conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)]
- LaMotte® 2020 or 2020e or 2020i Turbidity Meters
- Hand-held X-ray Fluorescence (XRF) analyzer

3. References

Consult the site-specific SAP for modifications that may be necessary to these procedures and check with the site-specific Health and Safety Plan (HASP) to determine if additional personal protective equipment (PPE) is required. Consult the appropriate Operators' Manuals for updated information regarding specific equipment.

4. Associated SOPs

EI-1008 Field Equipment Decontamination

EI-4014 Field Documentation and Forms

EI-5013 YSI® Water Quality Meter Operation and Routine Maintenance

EI-5202 Photoionization Detector Operation and Routine Maintenance (under review)

EI-5203 Turbidity Meter Operation and Routine Maintenance

5. Equipment

- Gloves (generally Nitrile but other materials may be acceptable based on SAP or HASP requirements)
- PPE required per the HASP or SAP based on site-specific hazards
- YSI® 6 Series Sonde with probes for required measurements
- YSI® handheld display and cord
- Ring stand and clamps
- Photoionization detector
- LaMotte® 2020/2020e/2020i
- Paper towels
- Lint-free disposable clothes
- Calibration solutions: pH 4, pH 10, conductivity, ORP, and zero DO, if required
- Plastic beakers (1 Liter)
- Small calibration vial
- Squirt bottle of deionized water
- Span gas and regulator (e.g., Isobutylene 100 ppm)
- Zero air cylinder, if required
- Tedlar® bag with connector tubing
- LaMotte® AMCO standards 1.0 and 10.0 NTU
- ***Documentation***: Field Instrument Calibration Record (Attachment 5) and field log book

6. Decontamination

All non-disposable equipment that comes in contact with contaminated media will be decontaminated prior to arrival on site, between sampling locations, and before leaving the site. Decontamination procedures will be followed in accordance EI-1008.

7. Calibration Procedures

Field instruments will be properly calibrated, charged, and in good working order. Performing daily calibrations and conducting calibration checks before and after use each day helps to ensure that instrument readings are accurate and can be used for the intended purpose.

All field instruments will be appropriately protected against inclement weather during operation and will be secured in a cool, dry place when not in use.

7.1 Photoionization Detectors

PIDs measure and display the total concentration of airborne vapors that can be ionized by the detector. The detector is sensitive, selective but non-specific and cannot distinguish between individual compounds. Only compounds with a ionization potential in electron volts less than the lamp energy are ionized and thereby detectable. The displayed reading reports the total concentration of all detectable VOCs in parts per million (ppm). Most PIDs are fitted with a 10.6 eV lamp while others can be fitted with either a 10.6 eV or an 11.7 eV lamp depending on the ionization potential of the site compounds of concern. The Photovac® 2020 and 2020PRO Plus discussed in Section 7.1.1 is limited to using only a 10.6 eV lamp. The MiniRAE® 2000 discussed in Section 7.1.2 can be outfitted with either a 10.6 or 11.7 eV lamp. It is extremely important to consult the site-specific SAP and HASP to make sure that the correct PID and lamp are used to detect site contaminants.

PIDs will be calibrated against ambient air and a standard reference gas of known concentration (span gas) at least twice each day. A calibration check will be conducted against both standards before use and at the end of each day. Calibration check results will be recorded on the Field Instrument Calibration Record. See Attachment 1 for photos of the MiniRAE® 2000.

7.1.1 Photovac® 2020 or 2020PRO Plus

1. Check to make sure that the PID and lamp are appropriate for detecting the site contaminants. If necessary, consult the SAP and HASP to determine appropriateness.
2. Make sure the regulator is turned all the way to the “off” position
3. Screw the regulator to the calibration gas cylinder
4. Open the valve on the Tedlar® bag, press to remove any air, and reclose the valve
5. Attach the Tedlar® bag inlet to the outlet of the regulator with the adaptor tubing
6. Slowly turn on the calibration gas regulator to slowly fill the Tedlar® bag with calibration gas
7. Close the calibration gas regulator, then close the Tedlar® bag valve and disconnect the bag from the regulator leaving the adaptor tubing on the Tedlar® bag inlet
8. Press the ***On/Off*** key on the PID instrument
9. Select ***Enter*** to access the menu
10. Select ***Set***
11. Select ***Cal***
12. Select ***Zero*** to zero the instrument. This process will take at least 60-90 seconds. Zeroing must be performed in a VOC-free environment. A cylinder of zero air may be used to fill a clean Tedlar® bag in order to zero the PID, if VOCs are present in ambient air.
13. Open the calibration gas Tedlar® bag and connect to the PID using the adapter tubing
14. Select ***Span***

15. At the prompt, enter the concentration of the calibration gas
16. Wait for the PID to complete the calibration (usually 1-2 minutes)
17. Remove the Tedlar® bag and close the valve
18. Approximately five minutes after the calibration is complete, sample ambient air (or zero air Tedlar® bag) and then the calibration gas Tedlar® bag again to ensure the PID has been calibrated correctly
19. Record the values for ambient air (or zero air Tedlar® bag) and the calibration gas on the Field Instrument Calibration Form
20. If either ambient air or the calibration gas standards does not meet accuracy goals below, the calibration should be redone.
21. Repeat Steps 18 and 19 at the end of the day. If accuracy goals are not met, the data should be considered estimated. If the value of the standards and the actual instrument reading vary by more than two times the accuracy goals the instrument should be re-calibrated more frequently to ensure worker safety.

Parameter	**Post-Calibration Check Accuracy Goals**
Ambient Air	<2 ppm
Span Gas	±10%

7.1.2 MiniRAE® 2000

1. Complete Steps 1-7 from Section 7.1.1.
2. Turn on the PID by depressing ***Mode*** for a full second
3. Wait for the PID to display a “Ready” message
4. If you are using isobutylene as your span gas skip to Step 9. If you are using a different span gas continue to Step 5
5. When prompted “Select Cal Memory?” press ***[Y/+]***. The display will read “Gas =” and “Mem # x?”
6. Press ***[N/-]*** to scroll through the memory numbers. Each memory number corresponds to a different span gas Cal Memory #0 = Isobutylene Cal Memory #4 = Styrene Cal Memory #1 = Hexane Cal Memory #5 = Toluene Cal Memory #2 = Xylene Cal Memory #6 = Vinyl Chloride Cal Memory #3 = Benzene
7. Press ***[Y/+]*** to make a selection
8. Press ***[Y/+]*** when display will reads “Save?”
9. Press and hold down ***Mode*** and ***[N/-]*** simultaneously (about 3 seconds) to enter the programming menu
10. Menu choices will appear on the screen; use ***[N/-]*** to scroll through the menu and ***[Y/+]*** to choose menu items
11. Zeroing must be performed in a VOC-free environment. A cylinder of zero air may be

used to fill a clean Tedlar® bag in order to zero the PID, if VOCs are present in ambient air. If Zero air is to be used connect the Tedlar® bag to the instrument.

12. When prompted “Fresh Air Cal?” press ***[Y/+]***. The display will show “zero in progress” followed by a countdown timer
13. After about 15 seconds the display will show “update data…zeroed”
14. Press any key and wait about 20 seconds. The monitor will return back to the submenu
15. Open the Tedlar® bag and connect to the PID using the adapter tubing
16. Scroll through the prompts as necessary using ***[N/-]*** until “Span Cal?” is displayed
17. Press ***[Y/+]*** to start the calibration. <u>Do not press down on the Tedlar® bag</u>!
18. Wait approximately 30 seconds until the countdown timer reaches 0. The calibration is complete.
19. Close the valve and remove the Tedlar® bag.
20. Approximately five minutes after the calibration is complete, sample ambient air (or zero air Tedlar ® bag) and then the calibration gas again to ensure the PID has been calibrated correctly.
21. Record the values for ambient air and the standard on the Field Instrument Calibration Form.
22. If either ambient air or the span gas standards do not meet accuracy goals below, the calibration should be redone.
23. Repeat Steps 20 and 21 at the end of the day. If accuracy goals are not met, the data should be considered estimated. If the value of the standards and the actual instrument reading vary by more than two times the accuracy goals the instrument should be re-calibrated more frequently to ensure worker safety.

Parameter	**Post-Calibration Check Accuracy Goals**
Ambient Air	<2 ppm
Span Gas	±10%

7.2 Water Quality Instruments

Water quality instruments come in a variety of configurations. Some measure a single parameter; while others can be outfitted with several different probes depending on the water quality indicators of interest (see Attachment 2).

Water quality instruments will be calibrated using standards of known values at least at the start of each day. Calibration checks will be conducted against the same standards before use and at the end of each day. Calibration check results will be recorded on the Field Instrument Calibration Record.

7.2.1 YSI® 6-Series Sondes

The following procedures are written specifically for YSI® 6-series sondes (including models 600R, 600XL, 600XLM, 6820, 6920, and 6600) and the YSI® 650 display/data logger. The general procedures below are applicable to similar instruments. Consult the manufacturer's operations manual for specific procedures and any relevant updates.

Temperature probe calibration cannot be performed by the operator. Temperature probes should be verified for accuracy on an annual basis using a National Institute of Standards and Technology (NIST) traceable thermometer. If values vary by more than 0.15°C the instrument should not be used and the manufacturer should be contacted.

1. Press the green power button "ϴ"**.** Allow the unit to warm up for 10 minutes and the calibration solution temperature to stabilize. If the calibration solutions are extremely cold, pour aliquots of each solution sufficient for calibration into separate clean beakers to expedite this process. Make sure to cover all calibration solutions when not in use.
2. Select **Calibrate** from the main menu
3. Use the up and down arrows on the calibration menu and select **Conductivity** and then hit enter "↵"
4. Select **spCond** and press ↵ to calibrate specific conductivity
5. Enter the value of the conductivity solution in mS/cm^3 using the number pad and press ↵**.** Note: The concentration on the standard may be in uS/cm^3. To convert the standard concentration from uS/cm^3 to mS/cm^3 divide by 1000.
6. Gently rinse the probes with deionized water
7. Submerge the probes with the protective probe cover into a clean beaker with a sufficient amount standard to completely cover the sensor. See Attachment 2 for help with identifying the different sensors. Note: The conductivity sensor is located in the vent hole on the side of the conductivity/temperature probe. If the probe guard must be removed to sufficiently submerge the sensor, take extra care to avoid damaging the probes.
8. Wait for the specific conductivity measurement to stabilize and press ↵ to calibrate. If the display reads "Out of Range" do not accept the value! Instead, check for the source of the problem and retry Steps 6 and 7. The problem may be not sufficiently submerging the probe or entering the wrong value for the calibration solution.
9. Wait for the "Calibrated" message on the display.
10. Press the escape key "Esc" or ↵ as prompted to return to the calibration menu.
11. Select **pH** and hit ↵ to calibrate pH.
12. Select **2-point and** ↵ to perform a standard 2-point calibration. Per the SAP, a 3-point calibration may be required. In this case, select **3-point** and ↵.
13. When prompted enter the pH value using the number pad (e.g., 4.0 and ↵) and repeat

Steps 6 through 10 for each pH standard value.

14. On the calibration screen select **ORP** and ↵ to calibrate oxidation-reduction potential
15. When prompted enter the value of the ORP solution and ↵. Note: The value of the ORP standard varies with temperature. The value marked on the ORP solution is the value of the solution at 25°C. If the current temperature is not 25°C, use the table on the package insert to determine the proper temperature corrected standard value.
16. Repeat Steps 6 through 10
17. On the calibration screen select **Dissolved Oxygen** and ↵ to calibrate DO
18. Fill the calibration cup with the wet sponge and approximately 1/8” of de-ionized water.
19. Remove any water droplets from the DO probe membrane with a wipe using a gentle dabbing motion.
20. Place the probe ends into the calibration cup. Engage only 1 or 2 threads to ensure the probe is vented to air. Do not allow any of the probes to contact the water in the calibration cup!
21. Wait 10 minutes to allow the air in the calibration cup to become water saturated
22. Select **% DO** and ↵.
23. Enter the barometric pressure in mm Hg and ↵. Note: Barometric pressure readings from weather services are usually corrected to sea level and cannot be used until they are “uncorrected”. If you need to determine the barometric pressure using weather service data and/or you need to convert a measurement to the proper units see the manufacturer’s operations manual for instructions.
24. Wait for the DO measurement to stabilize and press ↵ to calibrate. Record the stabilized value on the Field Instrument Calibration Form. The calibration steps are complete. You must now verify the calibration.
25. Press Esc as needed to return to the main menu.
26. Gently rinse the probes with de-ionized water.
27. Select **Sonde Run** and ↵.
28. Select **Discrete Sample** and ↵.
29. Submerge the probes in the first calibration solution and wait for the reading to stabilize. Once stabilization has been reached record the value on the Field Instrument Calibration Form. Gently rinse the probes with deionized water.
30. Repeat Step 29 for each of the calibration solutions. If required in the SAP, an additional calibration check can be performed using a zero DO solution.
31. Prepare the instrument to check DO - repeat Steps 18 through 21 and record the saturation value.
32. Determine if the post-calibration values meet accuracy goals displayed below:
33. If all accuracy goals are met, you may proceed with sampling. If only one parameter does not meet the above accuracy goal and the check value varies by less than two

times the accuracy goal you may also proceed with sampling but the data for that parameter should be considered estimated. If more than one parameter does not meet the accuracy goal or if a single parameter varies from the accuracy goal my more than 2 times, the affected parameters must be recalibrated.

34. Repeat Steps 27 to 32 at the end of the day. If accuracy goals are not met, the data should be considered estimated. If the value of the standards and the actual instrument reading vary by more than two times the accuracy goals, the instrument should be re-calibrated more frequently.

Parameter	**Post-Calibration Check Accuracy Goals**
pH	± 0.3 units
Conductivity	± 10 %
Oxidation Reduction Potential	± 10 mV
Dissolved Oxygen	± 0.5 mg/L of the saturated value
	< 1.0 mg/L for zero DO sol'n if using

7.3 Turbidimeters

7.3.1 LaMotte® 2020/2020e/2020i Turbidimeter

1. Press **On** to turn the meter on (see Attachment 3)
2. Press the arrow keys (↓ and ↖) to highlight “Measure” and enter **OK**
3. Wipe the tube containing the 0 NTU standard with a lint-free cloth
4. Open the meter lid and insert the tube into the chamber making sure the standard vial is filled adequately to the index line (see Attachment 3)
5. Align the index notch on the vial with the index arrow on the meter and close the lid
6. Select “Scan Blank” and press **OK**
7. Remove the tube and repeat Steps 3 through 5 using the 10 NTU standard
8. Select “Scan Sample” and press **OK**
9. Observe the result. Press the down arrow (↖) and **OK** simultaneously to select “Calibrate”
10. Press ↓↖ to change the highlighted digit on the display to the value of the standard and press **OK** to accept a digit and move to the next digit.
11. Press **OK** to select “Set” after all digits are updated
12. The calibration is complete. Press the back arrow (→) to exit to the previous menu.
13. To verify the calibration use the ↓↖ keys and select “Measure”
14. Insert each standard in turn and select “Scan Sample” and press **OK**

15. Record the values for each of the two standards on the Field Instrument Calibration Record. Verify the values meet the below criteria.
16. If accuracy goals are not met, rerun the calibration.
17. At the end of the day repeat Steps 13 through 15. If accuracy goals are not met, the data should be considered estimated. If the value of the standards and the actual instrument reading vary by more than two times the accuracy goals the instrument should be re-calibrated more frequently.

Parameter	**Post-Calibration Check Accuracy Goals**
Turbidity – 0 NTU Standard	±0.3 NTU
Turbidity – 10 NTU Standard	±10%

7.4 Handheld XRF Analyzers

Handheld XRF analyzers are invaluable for measuring real-time concentrations of heavy metals in soils, sediment, and on solid surfaces. Handheld XRF analyzers can measure concentrations of the heavy metals typically of concern at sites suspected of having environmental contamination. The measurements that the handheld XRF provides also typically correlate well with fixed laboratory analysis, making the XRF analyzer a reliable field screening instrument. See Attachment 4 for a picture of what a typical XRF analyzer looks like.

If used in the field, XRF analyzers will be calibrated in accordance with the manufacturer's instructions provided in the operating manual. If applicable, calibration will be completed using standards of known values at least at the start of each day. Calibration checks will be conducted against the same standards before use and at the end of each day. Calibration check results will be recorded on the Field Instrument Calibration Record.

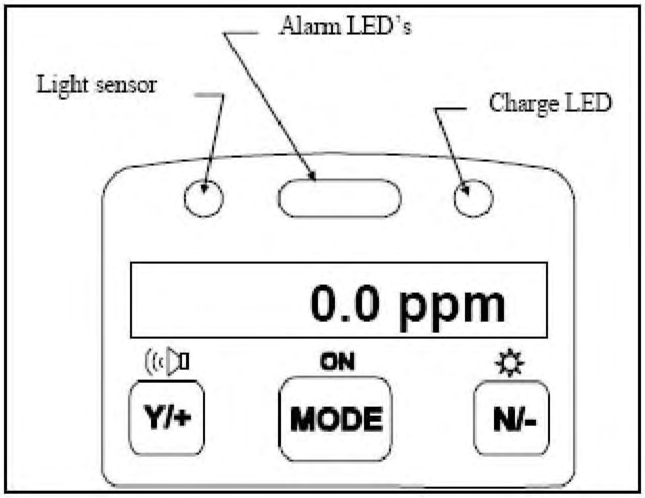
8. Documentation

A Field Instrument Calibration Record will be completed each day for each set of instruments. See Attachment 5.

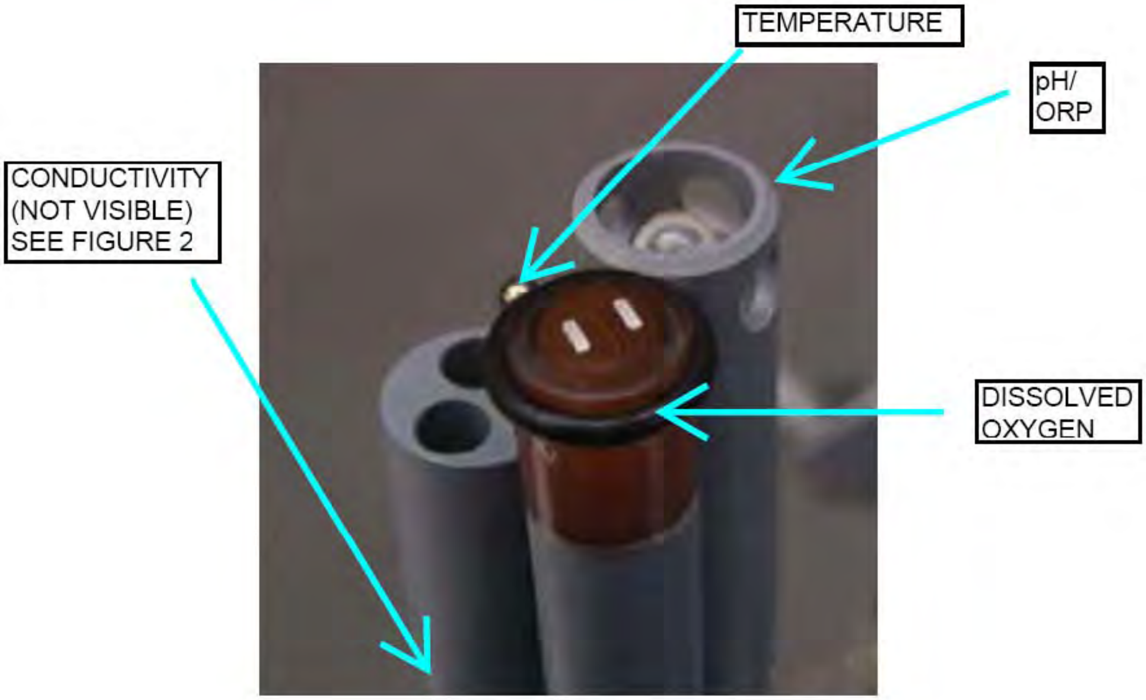
9. Measure of Proficiency

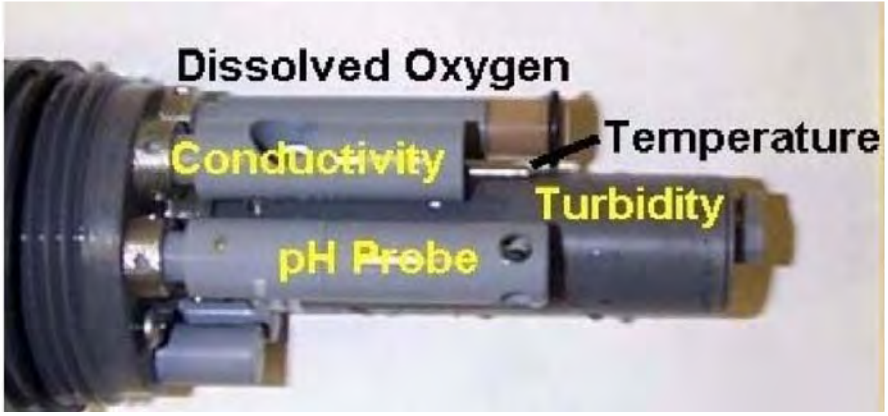
Field staff will demonstrate proficiency for calibrating a specific instrument by successfully completing the corresponding calibration procedure from Sections 7.0 and 8.0 a minimum of two times under the direct supervision of a Senior Associate with appropriate field experience or their designee.

Attachment 1: MiniRAE® 2000

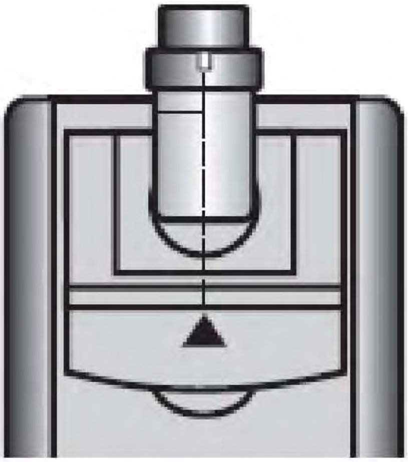


Attachment 2: YSI 6-Series Sonde Probes (top and side views)





Attachment 3: LaMotte 2020e Turbidity Meter



Attachment 4: Handheld XRF Analyzer

Attachment 5: Field Instrument Calibration Record

	Field Instrument Calibration Record				**Date:**	
					Client:	
					Project:	
					Project No.:	
MULTI-PARAMETER WATER QUALITY METER						
Meter Type/Model:					**Unit ID No.:**	
Initial Check:					**End of Day Check:**	
Parameter	**Standard Value**	**Meter Value**	**Acceptance Criteria**	**Criteria Met? (Y/N)**	**Meter Value**	**Criteria Met? (Y/N)**
pH			± 0.3			
Conductivity			± 10%			
ORP			± 10 mV			
DO			± 0.50 mg/L of saturation			
Zero DO*			< 1.0 mg/L			
Temperature*			± 2.0 C			
Other*						
*If required						
TURBIDITY METER						
Meter Type/Model:					**Unit ID No.:**	
Initial Check:					**End of Day Check:**	
Parameter	**Standard Value**	**Meter Value**	**Acceptance Criteria**	**Criteria Met? (Y/N)**	**Meter Value**	**Criteria Met? (Y/N)**
Low Standard			± 0.3 NTU			
High Standard			± 10%			
PHOTOIONIZATION DETECTOR						
Meter Type/Model:					**Unit ID No.:**	
Initial Check:		**Span Gas:**			**End of Day Check:**	
Parameter	**Standard Value**	**Meter Value**	**Acceptance Criteria**	**Criteria Met? (Y/N)**	**Meter Value**	**Criteria Met? (Y/N)**
Background			< 2 ppm			
Span Gas			± 10%			
XRF ANALYZER						
Meter Type/Model:					**Unit ID No.:**	
Initial Check:		**Metals:**			**End of Day Check:**	
Parameter	**Standard Value**	**Meter Value**	**Acceptance Criteria**	**Criteria Met? (Y/N)**	**Meter Value**	**Criteria Met? (Y/N)**
OTHER:						
Meter Type/Model:					**Unit ID No.:**	
Initial Check:					**End of Day Check:**	
Parameter	**Standard Value**	**Meter Value**	**Acceptance Criteria**	**Criteria Met? (Y/N)**	**Meter Value**	**Criteria Met? (Y/N)**
NOTES:						
Calibrator's Signature (initial):					**Date/Time:**	
Calibrator's Signature (end of day):					**Date/Time:**	

XRF Quality Assurance/Instrument Performance Form

PAGE______OF______

CALIBRATION CHECK	
	JOB NO.

XRF Analyzer Calibration Check

If an XRF analyzer is used to obtain environmental sample results in the course of the Assessment, the instrument must be calibrated prior to use and as directed by the manufacturer. Calibration checks should be made at the beginning of each job, every four hours during continuous operation, at the end of every job, and each time the instrument is turned on. If specified by the manufacturer, the XRF analyzer should be calibrated if there is a significant change in temperature in work environments as soon as the temperature of the instrument has had an opportunity to adjust.

Zero reading: ____________ **Acceptable Range:** __**0.0** +/-___________

Acceptable Control Range: _______________________

Reason for Check	Standard Used	XRF Reading	Accept or Reject	Corrective Action Number

Reason for Check

I.C. = Initial Calibration
Temp Calibration = Work Environment Temperature Change
4/Hour = Subsequent four hour check
T.O. = Resumed Assessment After Instrument was Turned Off
F.C. = Final Calibration

Corrective Action Number

1. Cleaned Instrument Face
2. Cleaned Zero Block/ Film
3. Manual Zero/ calibration
4. Consulted Manufacturer
5. Sent instrument to Manufacturer for service

Appendix B

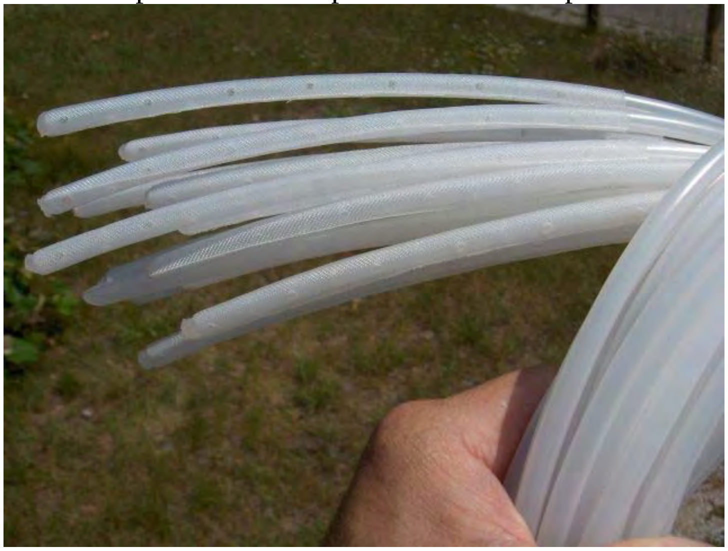
Porewater Sampling Equipment Information

Semi-permanent sediment pore water sampling systems.

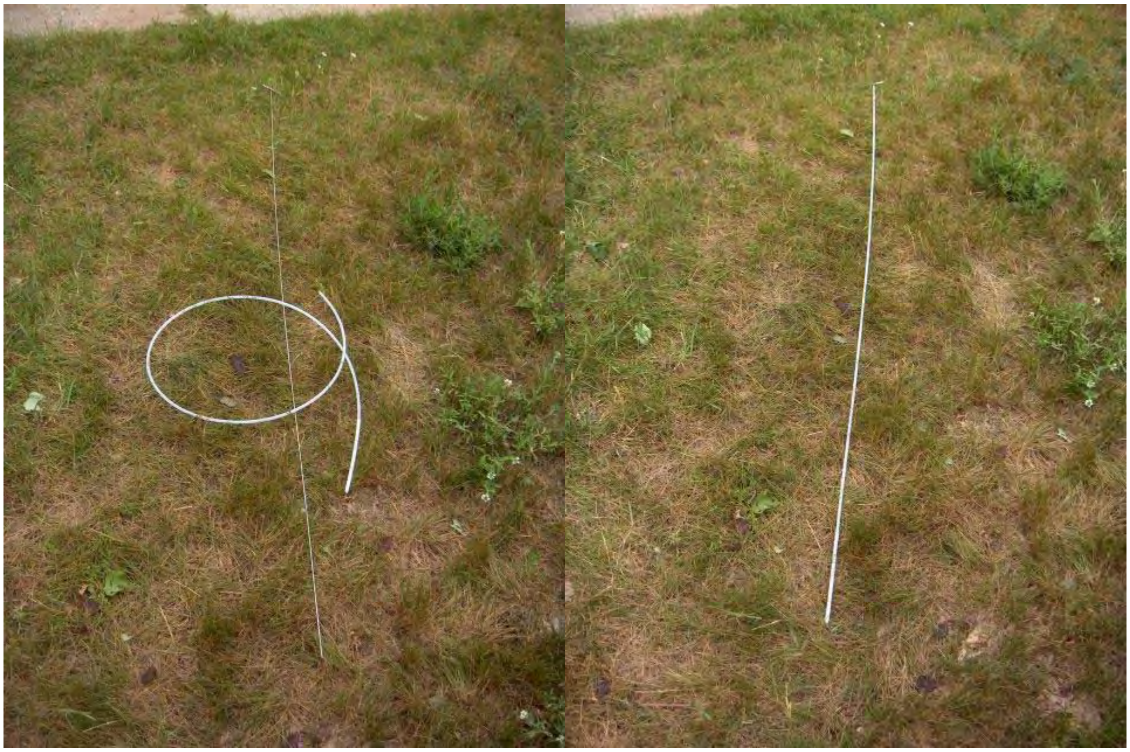
These are based on the simple and extremely effective MHEproducts “TubeWells” which are constructed of ¼” polyethylene tubing and fitted with a 10 cm polypropylene screen (54TPI).

Here’s a bundle of a dozen 7’ long “SedPoints”:

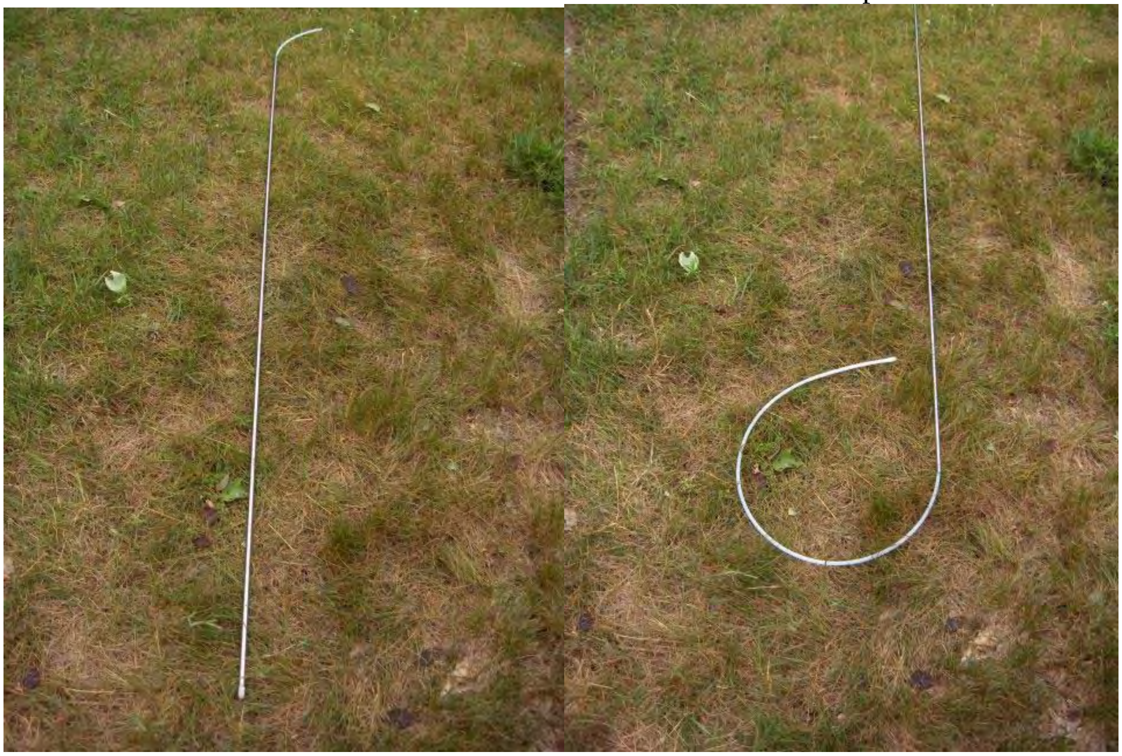
A close-up of the screen portion of the sampler:



These can be inserted into soft sediments by hand if the stainless steel T-handle guard-rod is used. The rod straightens out the tubing into a semi-rigid installation that can be pushed by hand and left in place once the guard-rod is removed. See below:



If you are concerned about smearing something down the hole from inserting an “unprotected” SedPoint into the sediments or would like to push into sandy seds, I have been developing a version that fits inside a stainless steel tube (SedPoint Insertion Tool). Once the SS tube has been inserted to the desired depth in the sediments, the SS tube is removed and the SedPoint is left in the sediments at that desired depth. See below:



Close-up of tip of 316 Stainless SedPoint Insertion Tool with and part of screen exposed prior to assembly for insertion into the sediments (note protective tip at end of screen):

To install SedPoints into saturated sediments for pore water sampling, load the top of the SedPoint into the Insertion Tool from the bottom of the tool, being careful to tuck the top of the polypropylene screen into the Tool before sliding the screen fully into the tool. The polyethylene protective tip should fit snugly against the stainless steel Tool tip and the excess ¼” polyethylene tubing should slide up through the Tool handle. The SedPoint loaded in the Insertion Tool can frequently be pushed into the sediments to the desired depth without pre-probing a hole. If this doesn’t work you should use a PushPoint or a slide-hammer “punch-bar” type pre-probe to open a ½” hole into the sediments. To install the SedPoint, first push the loaded Insertion Tool into the sediments to the desired depth. Then grasp the Tool handle and the excess polyethylene and gently push the poly tubing through the Tool handle at the same rate that you use the handle to pull the Tool from the sediments. This keeps the SedPoint at the same depth in the sediments while the Tool is removed and helps extrude the SedPoint screen from the Tool. Generally, once the screened portion of the SedPoint has been pushed from the Insertion Tool, resistance decreases and the Tool can be easily removed from the sediments while the SedPoint will simply slide through Tool. Usually in saturated sediments fine silt and sand will collapse around the SedPoint forming a good seal that will not allow surface water to be drawn down the bore hole.

If the SedPoint is to be used for soil gas investigation/monitoring, Use a pre-probe to create a ½” diameter hole into the soil to the desired depth – 5 to 6 feet is a good depth for many applications. If the hole stays open, a SedPoint can be slid to the bottom of the hole. If the hole does not stay fully open, the Insertion Tool should be used to set the SedPoint to the desired depth in the hole. Once the SedPoint is in place, pour dry fine sand into the hole (I usually use a 2-liter soda bottle full of sand for this purpose) to about 1 foot or so from the surface. Then pour a 2 “ plug of powdered bentonite (from another soda bottle) into the bore hole to seal the hole. Fill the hole the rest of the way to just below land surface with fine sand. Pour some water on to the boring to hydrate the bentonite. Natural soil moisture will eventually hydrate the bentonite powder.

Leave as much of a lead hanging out of the sediments as you wish and cap w/ vinyl cap to prevent surface water exchange when left in place for extended periods. Looks like this when you're done (Picture 1: SedPoints installed 5.5' and 3' into sedimentss, Picture 2: single SedPoint installed to 6'):

MHE Products PushPoint Sampler (US Pat. # 6,470,967)
Operators Manual and Applications Guide

Ver. 2.01 2/15/03

Models: PP27, PP14, PPX36, PPX72

Introduction

The groundwater/surface water interface (GSI) has been a research interest of mine for the past decade. This transitional zone is usually rich in biomass and may play a predominant role in the bioattenuation of contaminated groundwater entering surface water bodies. Usually these biologic processes have limited effectiveness in attenuating highly contaminated groundwater, leaving a plume of parent contamination and metabolic byproducts that eventually expresses itself in receiving waters - usually classified as non-point sources of pollution because of the uncertainty of the discharge area. Part of the problem in the detection and study of these plumes is that there were no devices on the market for the rapid, discrete collection of pore water samples. Reliance on conventional technology and techniques to perform a detailed investigation required extensive effort and burdensome equipment.

Through several iterations, I have evolved a simple device for collecting pore water samples from beneath surface water bodies or the beach areas surrounding them. Pore-water sampling using the PushPoint becomes a simple and efficient process, generating a wealth of information and very little waste. If one collects groundwater samples in a transect perpendicular to groundwater flow in the suspected area of plume discharge to an open water body, their analysis yields information about the aerial extent of contaminant discharge to the water body. At this point, additional sampling can complement the initial data and provide the information necessary to map the plume expression in both magnitude and aerial distribution. This is becoming increasingly important to regulators as they decide the ecological impacts of discharging contaminant plumes.

Sampling at each location usually takes 5 minutes, allowing a small crew to collect dozens of samples in an afternoon. These samples can be analyzed in the field for real-time information useful in directing field investigations and research. The work that I have conducted at several contamination sites indicates that many groundwater plumes discharge in surface water bodies in 2-3' of water depth - accessible to investigators wearing hip boots or waders. Many plumes, especially Light Non-Aqueous Phase Liquid (LNAPL) plumes can be delineated by collection of samples in very shallow water or from under beaches. My initial experience has shown that Dense Non-Aqueous Phase Liquid (DNAPL) contaminant plumes express themselves in the shallow, near-shore water as well, even though the on-shore depth of the contaminant mass was deep in the aquifer.

Directions

Look at Figure 1.

As you can see, the PushPoint device is a very simple, precisely machined tool consisting of a tubular body fashioned with a screened zone at one end and a sampling port at the other. The bore of the PushPoint body is fitted with a guard-rod that gives structural support to the PushPoint and prevents plugging and deformation of the screened zone during insertion into sediments. The PushPoint is made of 316 stainless steel assuring compatibility with most sampling environments. The screened-zone consists of a series of interlaced machined slots which form a short screened-zone with approximately 20% open area.

Operation of the device is not difficult. One simply holds the device in a manner that squeezes the two handles towards each other to maintain the guard-rod fully inserted in the PushPoint body during the insertion process (as shown in Figure 2). Holding the device in this manner, push the PushPoint into the sediments or beach to the desired depth using a gentle twisting motion. When the desired depth is reached (or you hit refusal, usually at an aquitard) remove the guard-rod from the PushPoint body without disturbing the position of the deployed sampler. Once the guard-rod has been removed from the PushPoint, it SHOULD NOT be reinserted into the device until the bore of the PushPoint has been thoroughly cleansed of all sand, silt, etc.

Attach a syringe or peristaltic pump to the PushPoint sample-port (see Figure 3) and withdraw water at a low-flow sampling rate (50-200 ml/min.). The first 20-50 ml of groundwater will be turbid. This is the "development" water and should be discarded. Once non-turbid aliquots have been withdrawn, representative samples can be collected for on-site and off-site analysis.

Cleaning and Maintenance

I cannot stress how important cleanliness and linearity are to the working life of the instrument. The PushPoint was designed as an indefinitely reusable device; potentially able to be reused hundreds of times. The tolerance between the guard-rod and the bore of the PushPoint is very small. Increases in this tolerance through abrasion and damage may allow silty material into this annular space, eventually jamming the guard-rod into the bore - maybe permanently!

Excess wear and abrasion can also be introduced if the guard-rod is inserted frequently when the PushPoint body is bent. All the small bends should be "undone" prior to reinsertion of guard-rod to avoid scraping the sides of the bore causing burrs. Before reinsertion of the guard-rod into the cleaned PushPoint, the device should be "straight as an arrow". Use caution when straightening the screened-zone, it is somewhat delicate without the guard-rod inside it, and can be broken through repeated bending. Similarly, the guard-rod should be bend-free and clean when inserted into the bore of the device. When a clean and straight PushPoint is assembled, the guard-rod should slide fairly easily through the PushPoint bore and its handle should seat against the sampling port.

Clean the exterior of the guard-rod and PushPoint body and screened-zone with a stiff brush and cleaning solution (soapy water).Cleaning and decontamination of the bore of the instrument is easily accomplished using the cleaning adapter provided. Remove the spray nozzle of a "garden sprayer" filled with cleaning solution. Connect the adapter as shown in Figure 4. Insert the sampling port of the PushPoint to the adapter and squirt ~ 100 ml of pressurized cleaning solution backwards through the sampler and out the screened-zone into a waste receptacle. Gently push the guard rod into the bore of the PushPoint to its end to dislodge any bridged material. Re-rinse the bore with cleaning solution. Follow this with a distilled water and/or methanol rinse. Reinsert the guard-rod and the device is ready to be used again.

In some instances it may be advantageous to force the cleaning solution through the screened-zone and out the sampling port. To do so, gently insert the screened-zone of the PushPoint into the cleaning adapter, making sure not to bend the screened-zone, until the entire screened-zone is within the adapter. The screened-zone is somewhat fragile. To avoid damage, do not bend the screen-zone during insertion into the adapter. Squirt cleaning solution through the sampler to a waste receptacle.

Helpful Hints, Information, and Cautions

- Multiple depths can be sampled in one hole if samples are collected, in order, from deepest to shallowest. Insert the sampler using a twisting motion until you reach refusal. Remove the guard-rod. **Do not push the sampler further into the sediments once the guard-rod has been removed as this may damage the screened-zone and plug the device with sediment**. Once sampling has been completed at this deepest depth, the PushPoint can be partially pulled from the hole to a new sampling elevation. Remember, to prevent screened-zone damage, do not to insert the PushPoint into the sediments without the guard-rod inserted into the PushPoint body. Alternately, multiple holes can be used to collect samples from multiple depths at a particular sampling location. If vertical sampling is performed in one hole, it is recommended that some type be device such as a sampling platform be used to prevent lateral movement and slippage of the PushPoint as sampling is conducted near the top of the hole (see Figure 3). This offsets the leverage of the instrument and reduces hole degeneration. A simple platform would be a plate of steel with a 3/16" dia. hole through its center and would serve the fundamental purpose of maintaining a rigid hole opening . MHE offers a 8" dia., heavy-duty steel sampling platform engineered for the precise sampling depth requirements of field research. If repeated shallow sampling is to be conducted, it may be more convenient to use a shorter sampler (i.e. MHE - PP14").

- If you wish to reuse the PushPoint sampler at a particular sampling location and want to clean the bore quickly while you're there so that the guard-rod may be safely reinserted, you can use a syringe filled with surface water or DI water to backflush the bore several times before reinserting the guard-rod. Use at least 100 ml of water. If you have too much trouble reinserting the guard-rod (i.e. grit), it will be necessary to use the standard cleaning procedures.
- If the screened-zone of the PushPoint becomes plugged while inserted in the sediments due to passage through "something", it is frequently possible to hydraulically/pneumatically shock the screened-zone free of adhering material while it is inserted into the sediments. Attach a large-volume (50 ml) syringe to the sampling port. In a quick motion, pull the syringe plunger most of the way back (creating a vacuum) and then immediately release the plunger - the plunger will slam to a neutral position, sending a shock wave through the bore of the PushPoint and may alleviate the problem.
- The PushPoint can be used as a piezometer to determine the static head of the groundwater and hence, the potential direction of groundwater movement. To do this, a tube is connected to the sample port as shown in Figure 5. A continuous stream of water is established from the syringe (or pump) to the screened-zone by pumping out any air remaining in the PushPoint /tubing. When the tube is disconnected from syringe, the static water level in the tube will represent the static water level at the depth that the screened-zone occupies. In some discharge areas I have found several feet of head differential, and when the tubing is removed, the PushPoint flows like a miniature artesian well.
- It is frequently possible to push the PushPoint through thin lenses of low-permeably material and collect samples from below them and gather valuable geochemical samples. At many of the sites where the PushPoint has been used, sampling from just below a layer of fine sand/silt/clay, one occasionally encounters seemingly large pockets of gas that seem to have coalesced and collected under this less permeable stratum. Analysis of these pockets may provide additional insight to predominant biological processes. It is likely true that the concentration of volatile chemicals in the groundwater has equilibrated with these bubbles which means that their presence in a sampling stream or syringe would not significantly affect the concentration of dissolved volatile organic chemicals (VOC's). In fact, if one assumes that equilibrium conditions exist, the concentration of VOC's in the bubbles is directly related the concentration in the surrounding groundwater. An different condition may exist if the groundwater is supersaturated with bacterial metabolic waste gasses and the negative pressure exerted by the pump (or syringe) initiates degassing of dissolved gasses from the groundwater. In this instance, VOC's would partition from the groundwater to the bubbles as they are formed in the sampling tubing (this is fairly evident if occurring). The consequence of this condition is that part of the dissolved contaminant mass has partitioned into the gas phase and unless the gas-phase is captured, quantified and accounted for, the native VOC concentration of the groundwater is not reflected by analysis of the groundwater alone. If this condition exists, the degassing effect can be minimized by decreasing the sampling rate to a rate more easily yielded by the sampled formation. With experience, it is easy to distinguish which of these conditions (or combination of conditions) exist and to what extent they affect sample quality.
- The internal volume of a PushPoint PP27 is approx. 1.5 ml. A 50 ml syringe full of distilled water, decon water, methanol, etc. will push about 33 volumes through the bore.
- When straightening the screened zone it is sometimes helpful to flush out the bore of the device with a cleaning solution and then insert the guard-rod to the area of the bend in the screened-zone. Gently unbend the portion of the screened-zone nearest the rod and carefully advance the rod to the next bend.

After the rod has been fully inserted into the screened-zone perform the final screened-zone, straightening until the guard-rod slides freely through it.

- If the sampling port of the PushPoint is above the static level of the water body, each time you remove the syringe or pump from the PushPoint sampling port, air will fill the bore of the PushPoint, allowing the water level in the bore to reach its static head. To avoid this plug of air from entering the subsequent syringe, attach a pinch clamp and/or a 3-way valve between the sampling port and the syringe or pump inlet as shown in Figure 7.
- I have conducted dye tests (concentrated uranine dye) by injecting concentrated dye under a perforated 1.5' diameter disk through which the PushPoint was inserted from depths of 3" - 12" into sediments. The goal of these tests was to determine whether or not surface water and dye are drawn into samples collected in near surface sediments (i.e. whether a cone of depression is formed). The results indicated that no surface water is drawn into samples even though sampling was conducted with a peristaltic pump at its maximum rate of 600 ml/min for several minutes.
- I usually couple my field investigations with global positioning system (GPS) identification of the sampling location. If conditions permit, a pin flag can be placed at the sampling location for later location by GPS - I usually use sub-meter grade GPS for this surveying. GPS can then used in the future to relocate previously sampled location even if certain site physical characteristics have changed (eroding shorelines, etc.). If long-term study of a shoreline is planned it will be useful to have an elevation benchmark established on shore that can be used as a reference. The elevation of the sampling locations can then accurately measured. This may be helpful in areas where sediment levels are not stable such as in erosional areas.
- Sampling by syringe has many advantages. This is my preferred field method due to its simplicity and versatility. It is useful to be able to collect several 50 ml syringes full of groundwater, store them on ice and perform the sample transfer to VOA vial, etc. under more controlled conditions. To transfer sample to a VOA vial, place the end of the transfer tube (Figure 8) to the bottom of the VOA vial. Dispense sample into the VOA vial and slowly withdraw the transfer tube from the vial maintaining the mouth of the transfer tube just below the sample surface. When the transfer tube is almost out of the vial, continue to dispense sample and leave an "anti-meniscus" of sample above the rim of the vial. Add several drops of HCl (which will displace a few drops of sample) and cap. If VOC samples are to be collected and/or stored temporarily in a syringe, I recommend 100% polyethylene/polypropylene ("two piece") syringes such as those made by Henke Sass Wolf GMBH (NormJect ®, 50 ml)) configured as shown in Figure 8. From personal experience I have found that small amounts of aromatic compounds (BTEX) can leach from the rubber parts of the rubber-tipped plunger found in common medical syringes. Rubber-tipped plunger syringes have less side-wall resistance and work much smoother than the 100% polyethylene/polypropylene syringes so I use medical syringes for "development" of the PushPoint. Standard medical syringes also work well for collecting samples for non-VOC analysis. I utilize handheld meters for pH, conductivity, redox, DO, etc. One can dispense sample from the syringe into these types of instruments for field measurements. The disposable syringes may be cleaned and reused several times, but because they are a friction fit; prolonged reuse results in scoring of the barrel which eventually causes air leaks.
- The 50 ml, 100% polyethylene/polypropylene "two piece" syringes mentioned above can be purchased directly from MHE, configured with tubing, clamp, and stopper as was the example syringe included with your order, or customized to suit your individual needs. If you would to make your own, the syringes that I am currently using are purchased from National Scientific. The tubing is Tygon 1/4"OD x 1/8" ID. Be sure to use some type of clamp at the tubing mouth to ensure a good seal at the sampler port. The entire syringe assemblies are now available from MHE at a reasonable cost.
- Headspace GC analysis of VOC's can be easily accomplished using 100% polyethylene/polypropylene syringes. Dispense all but 25 ml of the sampled groundwater from the syringe. Refill the syringe to the 50 ml mark with ambient air and then stopper the tubing (and heat the syringe in a water bath if desired) as shown in Figure 9. Shake the syringe assembly to equilibrate the VOC's in the sample with the contained atmosphere. Insert a GC syringe needle through the transfer tube into the sample syringe headspace and withdraw a sample for GC analysis.
- Occasionally a small amount sand and silt is withdrawn into the syringe or pump sampling stream, even after proper "development" of the PushPoint. This may be due to the nature of the geologic formation. This fine material is probably already at equilibrium with the surrounding groundwater and

tests have shown that its presence should not influence analysis of VOC's in the groundwater sample. The sample can be transferred to its shipping container without this silt if the syringe is dispensed in such a manner as to let the solid material settle out in the syringe and not carry over to the shipping vial.

- The PushPoint has been used very successfully for underwater investigations using SCUBA equipment and a series of 100% polyethylene syringes. Once again, GPS equipment was used for location of the position that the divers collected groundwater samples of contaminant plume expression in the lake. Underwater notes (temperature, depth, observations, etc.) can be written directly on the sample syringes if they are pre-prepared with a strip of Scotch Magic Transparent Tape applied down the syringe body and writing is done with a soft pencil.
- The PushPoint may be used to inject nutrients or dyes into the sediments for field trials of biologic or geochemical testing or tracing groundwater paths. Simply insert the PushPoint to the desired depth, and after the guard-rod has been removed, connect a syringe or pump and slowly inject the desired fluid into the sediments, perhaps followed by a small amount of native groundwater to flush the instrument.
- The PushPoint is constructed of 316 stainless steel as mentioned previously. There are two places where the stainless parts are silver soldered together, the handle of the guard-rod and the handle on the PushPoint sampler. If the investigator is collecting samples for metals analysis, the silver solder joint on the guard-rod may impart trace levels metallic residue to the sampling port mouth. This has never caused a problem but the possibility exists. The silver solder that I use is Safety-Silv 45 which contains silver (45%), copper (30%),and zinc (25%). MSDS available upon request. In the unlikely event that these metals cause contamination of samples, MHE can produce specialty guard-rods that are not silver soldered. What can I say, these devices were originally built to sample for VOC's.
- These devices can be dedicated as semi-permanent underwater monitoring devices. If a PushPoint is inserted to the desired depth through a plate (such as the sampling platform mentioned earlier) that can lock the sampler at the correct insertion depth, a vinyl cap can be placed over the mouth of the sampler, and the sampler can be dedicated to that location so that future samples can be withdrawn when desired.
- It has been useful to carry several samplers in "quivers" made of 2" PVC tubing….one tube for (10-15) clean/assembled samplers and one tube for used samplers and their separated guard-rods. This arrangement protects both the investigators and the instruments.
- I have been using a Myron 6P Ultrameter available from www.ColeParmer.com for most of my work. This instrument measures pH, specific conductance, ORP, temperature, and TDS using only a few milliliters of sample and is perfectly suited to samples dispensed by syringe. The instrument is waterproof to 3 m. There will soon be a link on the MHEproducts.com web page.
- I have been using the Chemetrics Vacu-Vial technique (www.Chemtrics.com) in conjunction with Pushpoint sampling. I use this for dissolved oxygen and dissolved iron measurements. Many other analytical tests are also available such as nitrate, phenols, etc.. This analytical technique also works very well with samples collected in syringes. The sample is dispensed into a plastic cone until it overflows. The tip of an evacuated ampoule containing the necessary reagents is broken off at the bottom of the cone allowing the vacuum in the ampoule to pull in a aliquot of sample that has not contacted the atmosphere. The ampoule is shaken and is then is then placed as a cuvette into a handheld spectrophotometer. The results are nearly instantaneous and are displayed in ppm. There will soon be a link on the MHEproducts.com web page.

I hope that users will find many useful and innovative uses for this device. If you have other helpful information, uses, and advice concerning these samplers, please write or e-mail suggestions to me for inclusion in future manual revisions. I have finally started a web site: www.MHEproducts.com and have posted pictures, new products, and the latest version of this manual.

Thanks. MHE

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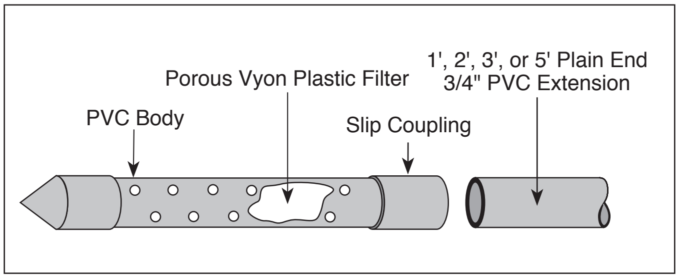
Solinst®

Standpipe Piezometer Instructions

Model 601



Operating Principles

Standpipe Piezometers are designed for placement within a drilled hole to provide a filtered inlet point. Piezometers can also be manually pushed into suitable sediment, such as very loose sands at the base of a borehole, a stream, or into very loose tailings pond sediments.

After the Standpipe Piezometer is installed to depth, groundwater enters through the porous piezometer filter and into the riser pipe, allowing water level monitoring, metals sampling, permeability measurements, slope stability tests, etc. The 60-micron filter inlets in the Piezometer Tip are also ideal for air sparging and VOC sampling.

Installation

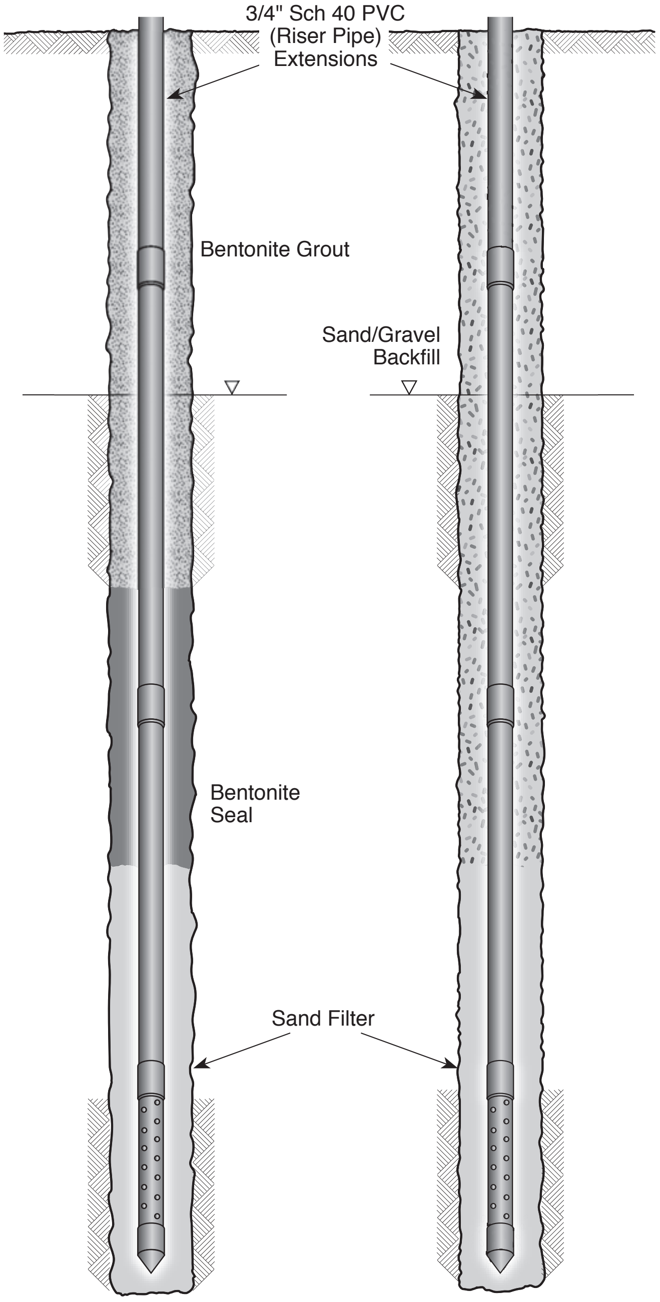
Component List

- Piezometer Tip lengths: 6", 1', 2', 3'
  (15 cm, 30 cm, 60 cm, 90 cm)
- Plain end 3/4" ID Sch 40 PVC Extensions
  (as required to reach desired depth)
- Slip Couplings (one required for each Extension)
- 3/4" Sch 40 PVC Slip Cap
- Optional Reducer Couplings
  (used to connect to other sizes of riser pipe)

1. Ensure that all components are clean prior to use.
2. Push the first PVC extension into the slip coupling connected to the Piezometer Tip.
3. Add couplings and extensions until the desired length is reached, and install the Piezometer downhole.

Note: If pushing the Piezometer into loose sediment, you can add couplings and extensions as the Piezometer Tip is advanced, until it reaches the desired depth.

4. After the Piezometer Tip and riser pipe are installed to depth, the installation can be completed by backfilling sand around the filtered Piezometer Tip and finished with sand, gravel or bentonite to the surface, depending on your application. Finish the installation with a slip cap on the top of the final PVC extension.



Typical Standpipe Piezometer Installations

Note: Avoid attempting to pull Model 601 Piezometers out of the soil after placement, since they are held together by friction fit only.

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Solinst®

Drive-Point Piezometers

Model 615 Data Sheet

Stainless Steel Drive-Point Piezometers

Model 615

The Model 615 Drive-Point Piezometer is designed as an affordable method to monitor shallow groundwater and soil vapor in suitable conditions.

The Drive-Points attach to inexpensive 3/4" (20 mm) NPT steel drive pipe which is widely available through local plumbing and hardware stores.

Solinst Drive-Point Piezometers are most often installed as permanent well points. They can also be used for short term monitoring applications.

High quality samples can be obtained if polyethylene or Teflon® lined tubing is attached to the stainless steel drive point. Groundwater sampling and hydraulic head measurements can be taken within the tubing using small diameter equipment, as described overleaf.

Solinst Drive-Point Piezometers can be driven into the ground with any direct push or drilling technology, including the Manual Slide Hammer shown at right. To avoid clogging or smearing of the screen during installation, a shielded version is also available.

Model 615 Drive-Point and Shielded Drive-Point Piezometer

Applications

- Groundwater sampling, including VOCs
- Water level monitoring
- Base flow monitoring in stream beds
- Contaminant plume delineations
- Soil gas sampling
- UST monitoring
- Low cost and minimal disturbance site assessment
- Sparge points

Installing Piezometers with a Manual Slide Hammer

High Quality Samples

The Model 615 Piezometer has a stainless steel, 50 mesh cylindrical filter-screen, within a 3/4" (20 mm) stainless steel drive-point body, screen support and a barbed fitting for attachment of sample tubing. Optional heavy-duty extension couplings are also available to create a strengthened and more rugged piezometer.

The inner barbed fitting allows connection of 5/8" OD x 1/2" ID (16 mm x 12 mm) LDPE or Teflon sample tubing. This prevents sample water from contacting the steel extension rods, and maintains high sample integrity, even when inexpensive carbon steel extensions are used.

Ideal for soil vapor sampling. Where an air-tight connection is most desirable, the compression fitting option allows users to attach 1/4" (6 mm) sample tubing directly to the top of the screened portion of the drive-point.

The 615 S shielded drive-point has a single use, 1-1/2" (38 mm) dia. shield to avoid smearing and plugging of the screen during installation. The strengthened connector at the top of the drive-point acts as an annular seal, which avoids contamination from higher levels in the hole.

The 615 N, designed without a tubing barb, is to be used for water level measurements. This saves money and provides better access for Water Level Meters.

Solinst®

Drive-Point Piezometers

Sampling Within Narrow Diameters

Direct push sampling has quickly become a popular way to obtain groundwater samples. However, sampling within drive-points requires a narrow diameter sampler. Solinst offers several options for this specific sampling application.

Peristaltic Pump, Model 410

The Peristaltic Pump uses the suction lift principle. Suitable for 1/4" (6 mm) ID or larger diameters. The Peristaltic Pump provides a regulated and steady flow. It works effectively up to 33 ft. (10 m) at sea level.

WaTerra Pump, Model 404

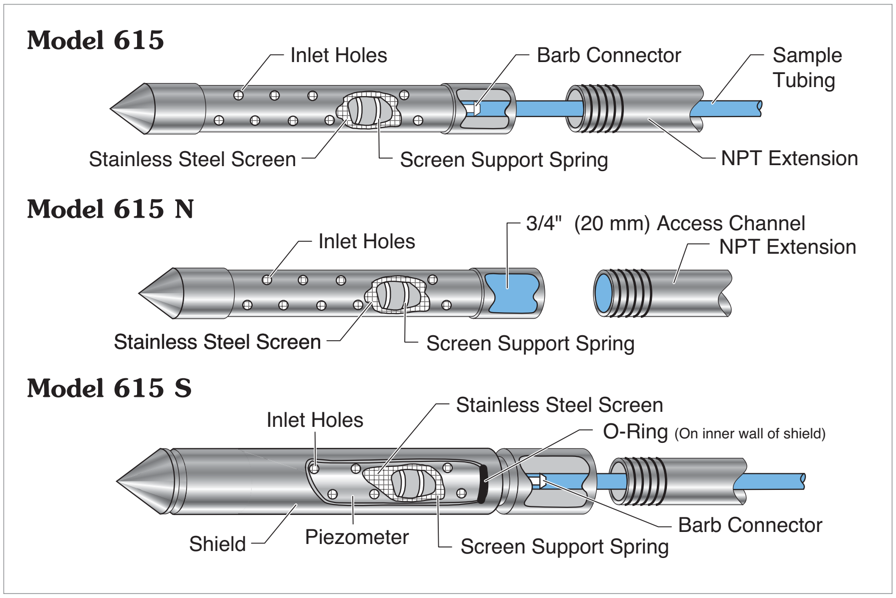
The WaTerra Pump operates as an inertial pump. A check valve and tubing, is raised and lowered to lift a sample. The SS10 foot valve suits wells as narrow as 1/2" (12 mm) ID and works to depths of 74 ft. (25 m).

Miniature Point Source Bailer, Model 429

The 1/2" (12 mm) dia. stainless steel bailer works very well in the 615N. The bottom emptying device permits a regulated, steady flow.

Hydraulic Head

Water levels can be measured in any of the drive-points described, using a Solinst Model 102, or the Narrow Tape Solinst Model 101 or 101M Water Level Meter for the most accurate hydraulic head measurements.



Manual Slide Hammer

For the most inexpensive wellpoint installations, the Manual Slide Hammer can be used to install the Solinst Drive-Point Piezometers. The 25lb (11Kg) slide hammer and all other equipment can easily be transported in a car or truck to most sites.

A heavy duty drive head is used, on which the slide hammer impacts, and a tubing by-pass ensures that the tubing does not get damaged during installation.

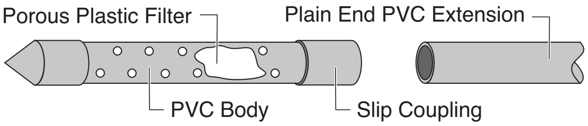
Couplings

Heavy duty couplings are available for the Model 615 Drive-Point Piezometers. The reinforced shoulder gives added support to the pipe threads, to withstand driving stresses and to give more accurate alignment. The maximum OD is 1.5" (38 mm).

Depth Limitations

Drive-point piezometers are not suitable for all sites. The depth limitations vary, especially with soil conditions and the drive method used.

Model 601 Standpipe Piezometer



The Model 601 Standpipe Piezometer, is the least expensive of the piezometer line, and is designed to be placed within an open hole. The pointed PVC tip is suitable for pushing into very loose sands at the base of a borehole, or for backfilling in place within test pits.

The piezometer uses a porous plastic filter set inside a perforated PVC body. It connects to the surface with 3/4" ID PVC riser pipe connected with slip couplings. The piezometer tips come in a variety of lengths.

Ideal for:

- Water level monitoring
- Construction control
- Slope stability investigations
- Soil gas monitoring
- Permeability measurement
- De-watering/drainage operations
- Metals monitoring

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Porewater Sampling Field Data

Location	Longitude	Latitude	Date	Sample Type	Water Quality Parameters								Notes
					Time	Temperature (˚C)	pH	Specific Conductance (uS/cm)	ORP (mV)	Dissolved Oxygen (mg/L)	Turbidity (NTU)	Ferrous Iron (mg/L)	
Midstream Bar (near International Border)													
MSB 1	-117.639222	48.996954	8/4/2010	porewater	7:23 PM	17.4	6.91	190	183	8.89	--	0.00	pushed sedpoint approx 3 ft into sediment
				surface water		19.5	7.11	125	169	9.64	--		water clear, turbidity meter malfunction
			8/5/2010	porewater	8:54 AM	18.6	7.27	167	180	7.94	54.1	0.21	
				surface water		18.7	7.51	119	153	9.28	130		
MSB 2	-117.639686	48.996563	8/4/2010	porewater	6:48 PM	14.6	6.09	191	186	6.96	52.2	0.09	
				surface water		19.8	6.44 - 6.58	124	160	9.79	120		turbidity - sampling in standing water and disturbing bottom
			8/5/2010	porewater	8:17 AM	14.7	6.66	201	181	6.98	22.0	0.00	
				surface water		18.5	6.79	120	181	9.34	8.7		
Black Sand Beach													
BSB 1	-117.648299	48.970662	8/3/2010	porewater	4:15 PM	23.7	6.72	209	175	1.01	10.5	0.00	
				surface water		25.5	7.34 - 6.89	210	180	8.15	17.8 - 0.0		
			8/4/2010	porewater	6:34 AM	20.4	6.66	207	174	2.24	0.0	0.00	
				surface water		19.0	6.98	211	157	6.77	0.0		
BSB 2	-117.648619	48.970788	8/3/2010	porewater	5:12 PM	19.1	7.10	124	208	7.63	9.7	0.03	
				surface water		18.9	7.20	127	194	9.72	6.6		
			8/4/2010	porewater	7:04 AM	18.2	7.22	127	180	7.59	--	0.05	river water level approx 2.5' lower than PM sample
				surface water		17.6	7.31	119	170	9.80	9.1		
Deadman's Eddy													
DE 1	-117.730300	48.940395	8/4/2010	porewater	4:56 PM	15.5	6.68	333	174	3.21	24.3	0.03	
				surface water		22.9	6.99	134	159	10.16	15		
			8/5/2010	porewater	6:14 AM	14.3	6.55	303	165	5.84	22.7	0.05	
				surface water		17.8	6.97	141	147	8.30	52.9		
DE 2	-117.732736	48.940002	8/4/2010	porewater	5:35 PM	16.7	7.08	398	189	7.19	60.0	0.02	
				surface water		20.1	7.50	127	164	9.47	27.9		
			8/5/2010	porewater	7:04 AM	15.7	6.56	298	184	6.87	16.3	0.21	
				surface water		18.0	6.78	120	152	9.21	11.2		
Upstream of Deadman's Eddy													
UDE 1	-117.720494	48.942108	8/5/2010	porewater	5:16 PM	18.8	6.75	178	131	7.93	47.3	0.02	
				surface water		19.7	6.48	126	75	9.90	67.6		
			8/6/2010	porewater	6:36 AM	17.2	6.29	178	150	7.05	0.0	0.00	river water level approx 3' lower than PM sample
				surface water		17.5	6.64	131	132	9.12	0.0		
UDE 2	-117.721607	48.942362	8/5/2010	porewater	6:06 PM	22.2	7.13	201	140	0.24	51.9	0.01	pushed sedpoint approx 2.5 ft into soft sediment
				surface water		32.2	7.83	169	103	8.29	19.2		nearby ponded water approximately 1 ft deep
			8/6/2010	porewater	7:13 AM	20.4	6.69	204	161	2.56	0.0		WQ meter stopped functioning; purged sedpoint for approx 10 min - started sampling at 7:25am
				surface water		16.8	6.84	250	--	0.56	--		

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Environment International, LTD.
Attn: Whitney Fraser
5505 34th Ave. NE
Seattle, WA 98105

RE: UCR Pore Water
Fremont Project No: CHM100809-3

August 12th, 2010

Jennifer:

Enclosed are the analytical results for the ***UCR Pore Water*** soil and water samples to Fremont Analytical on Monday August 9th, 2010.

Sample Receipt:
The samples were received in good condition - in the proper containers, properly sealed, and labeled. The samples were received in the following containers:

Container Type	Quantity	Preservative
500mL High-density polyethylene (HDPE) Bottle	40	HNO_3
250mL HDPE Bottle	18	
250mL Glass Amber	16	H_2SO_4
8oz Sample Jar	10	
8oz Sample Jar	8	

The samples were received in coolers with wet ice, with the following cooler temperatures:

Cooler 1	9.2°C
Cooler 2	6.3°C
Cooler 3	8.6°C
Cooler 4	9.6°C

All cooler were within the laboratory recommended cooler temperature range (<4°C - 10°C). The samples were stored in a refrigeration unit at the USEPA-recommended temperature of 4°C ± 2°C.

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Seattle, WA 98105

RE: UCR Pore Water
Fremont Project No: CHM100809-3

Sample Analysis:
Examination of these samples was conducted for the presence of the following:

- ***Total Metals in Soil by EPA Method 6020***
- ***Total Mercury in Soil by EPA Method 7471A (CVAA)***
- ***Total Metals in Water by EPA Method 200.8***
- ***Dissolved Metals in Water by EPA Method 200.8***
- ***Total Mercury in Water by EPA Method 7470 (CVAA)***
- ***Dissolved Mercury in Water by EPA Method 7470 (CVAA)***
- ***Dissolved Silica in Water by EPA Method 200.8***
- ***Anions (Full Scan) by EPA Method 300.0***
- ***Total Organic Carbon in Soil by EPA 9060A***
- ***Total Organic Carbon in Water by SM 5310B***
- ***Total Alkalinity by SM 2320B***

These applications were performed under Washington State Department of Ecology accreditation parameters. All appropriate Quality Assurance / Quality Control method parameters have been applied.

Laboratory Notations:

SW6020 (Metals in Soil):

- The *Laboratory Control Sample (LCS)* was within range for all analytes.
- High matrix interferences were present:
  - Sample ID: UDE 1 SED: The *relative percent difference (RPD%)* between the sample and sample duplicate exceeded recommended control limits (20%) for *Antimony (Sb) and Cadmium (Cd).* All other analyte Sample/Sample Duplicate *RPD%* values were within range.
  - Sample ID: UDE 1 SED: The *Matrix Spike (MS) and MS Duplicate (MSD)* for the analytes showed poor or no recoveries due to high concentrations of the analytes in the sample and due to the sample matrix. *Post Digestion Spike (PDS)* was run for select analytes. No *PDS* recoveries were obtained for *Calcium (Ca)*, Iron (Fe) and *Zinc (Zn)*. And secondary *MS/MSD* (batch sample) was also included in the run. All recoveries were within the project designated range (75%-125%).

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Analytical

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RE: UCR Pore Water
Fremont Project No: CHM100809-3

(Laboratory Notations cont.)

EPA 200.8 (Total Metals in Water):

- The *Laboratory Control Sample (LCS)* was within range for all analytes
- *Potassium (K)* was analyzed in a separate run due to poor QA/QC.
- Matrix interferences were present:
    - (MSB 1 PW AM): The *relative percent difference (RPD%)* between the sample and sample duplicate exceeded project recommended control limits (20%) for *Arsenic (As), Cobalt (Co), Copper (Cu) and Zinc (Zn)*. Separate bottles were provided for the sample duplicate. Note: All results were less than 25 times the reporting limit. All other analyte *RPD%* values were within range.

EPA 200.8 (Dissolved Metals in Water):

- *Chromium (Cr)* was detected in the method blank.
- The *Laboratory Control Sample (LCS)* was within range for all analytes

EPA 300.0 (Anions):

- The *MS* and *MSD* for *Ortho-Phosphate* were outside of the laboratory control limits. The *LCS* was within range. A *Continuing Calibration Verification (CCV)* was added and was also within range. All samples were non-detect for *Ortho-Phosphate*.

Please contact the laboratory if you should have any questions about the results.

Thank you for using Fremont Analytical!

Sincerely,

M Clements

Michelle Clements
Lab Manager / Sr. Chemist

mclements@fremontanalytical.com

Fremont Analytical

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Analysis of Total Metals in Soil by EPA Method 6020

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 6020 (mg/kg)	**MRL**	**Method Blank**	**LCS**	**UDE 2 SED**	**BSB 1 SED**	**BSB 2 SED**	**DE 2 SED**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Matrix				Soil	Soil	Soil	Soil
Aluminum (Al)	5.5	nd	97.0%	**12,400**	**21,900**	**24,600**	**17,200**
Antimony (Sb)	0.20	nd	95.7%	**3.83**	**18.8**	**15.1**	**14.3**
Arsenic (As)	0.10	nd	73.5%	**7.60**	**75.3**	**69.9**	**21.9**
Barium (Ba)	0.50	nd	85.3%	**347**	**1010**	**1250**	**845**
Beryllium (Be)	0.20	nd	125%	**0.730**	**4.26**	**4.13**	**1.34**
Cadmium (Cd)	0.05	nd	89.0%	**3.90**	**4.56**	**4.13**	**1.13**
Calcium (Ca)	10	nd	92.4%	**33,200**	**62,700**	**70,000**	**48,300**
Chromium (Cr)	0.10	nd	88.2%	**34.5**	**148**	**168**	**80.0**
Cobalt (Co)	0.20	nd	88.7%	**11.2**	**100**	**106**	**44.4**
Copper (Cu)	0.10	nd	86.0%	**507**	**1760**	**2190**	**1390**
Iron (Fe)	5.5	nd	99.5%	**82,400**	**156,000**	**173,000**	**123,000**
Lead (Pb)	0.50	nd	92.8%	**280**	**319**	**281**	**251**
Magnesium (Mg)	10	nd	96.6%	**11,600**	**9890**	**8400**	**5250**
Manganese (Mn)	0.20	nd	76.6%	**2630**	**7010**	**7690**	**5390**
Nickel (Ni)	0.10	nd	86.5%	**8.32**	**64.7**	**59.4**	**10.8**
Potassium (K)	50	nd	73.1%	**2210**	**5640**	**6270**	**4840**
Selenium (Se)	0.50	nd	79.3%	**0.733**	**5.77**	**4.02**	**0.350**
Silver (Ag)	0.10	nd	78.3%	**1.16**	**8.06**	**8.03**	**4.00**
Sodium (Na)*	10	nd	100%	**643**	**3050**	**3250**	**1040**
Thallium (Tl)	0.20	nd	93.6%	**1.68**	**3.01**	**2.69**	**0.910**
Vanadium (V)	0.10	nd	80.3%	nd	nd	nd	nd
Zinc (Zn)	0.40	nd	72.7%	**7300**	**16,900**	**18,600**	**8460**

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
Al, Ca, Fe, Mg, K, Na = 2000 µg/L
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 100 µg/L
Pb = 50 µg/L
Be, Se = 10 µg/L
Sb, Cd, Ag = 5 µg/L
Tl = 2.5 µg/L

Analysis of Total Metals in Soil by EPA Method 6020

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 6020 (mg/kg)	MRL	DE 1 SED	MSB 1 SED	MSB 2 SED	UDE 1 SED	Duplicate UDE 1 SED	RPD %
Date Extracted		8/10/10	8/11/10	8/11/10	8/11/10	8/11/10	
Date Analyzed		8/10/10	8/11/10	8/11/10	8/11/10	8/11/10	
Matrix		Soil	Soil	Soil	Soil	Soil	
Aluminum (Al)	5.5	**25,600**	**10,400**	**13,400**	**16,700**	**18,200**	9%
Antimony (Sb)	0.20	**3.32**	**2.84**	**6.59**	**7.30**	**4.37**	50%
Arsenic (As)	0.10	**8.32**	**7.66**	**9.33**	**13.2**	**13.5**	2%
Barium (Ba)	0.50	**415**	**268**	**468**	**678**	**752**	10%
Beryllium (Be)	0.20	**1.23**	**0.770**	**0.910**	**1.38**	**1.44**	4%
Cadmium (Cd)	0.05	**1.86**	**1.59**	**1.95**	**1.68**	**2.07**	21%
Calcium (Ca)	10	**50,000**	**21,400**	**30,100**	**49,800**	**54600**	9%
Chromium (Cr)	0.10	**48.4**	**22.0**	**34.2**	**66.2**	**75.8**	14%
Cobalt (Co)	0.20	**17.9**	**8.64**	**10.0**	**30.9**	**36.8**	17%
Copper (Cu)	0.10	**1100**	**410**	**552**	**1100**	**1240**	12%
Iron (Fe)	5.5	**144,000**	**60,500**	**41,200**	**110,000**	**125,000**	13%
Lead (Pb)	0.50	**442**	**265**	**232**	**231**	**246**	6%
Magnesium (Mg)	10	**7240**	**3840**	**2070**	**8830**	**9880**	11%
Manganese (Mn)	0.20	**4360**	**2970**	**1910**	**4820**	**5590**	15%
Nickel (Ni)	0.10	**6.16**	**5.05**	**2.70**	**8.08**	**9.10**	12%
Potassium (K)	50	**5140**	**2900**	**1910**	**5490**	**5570**	1%
Selenium (Se)	0.50	**0.260**	**0.870**	**0.560**	**0.210 *J***	**0.721**	-
Silver (Ag)	0.10	**2.11**	**0.890**	**0.630**	**2.59**	**2.66**	3%
Sodium (Na)*	10	**963**	**391**	**472**	**1450**	**1650**	13%
Thallium (Tl)	0.20	**1.68**	**0.960**	**1.38**	**1.41**	**1.52**	8%
Vanadium (V)	0.10	nd	nd	nd	nd	nd	
Zinc (Zn)	0.40	**9400**	**4670**	**5450**	**12,600**	**14,300**	13%

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"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
Al, Ca, Fe, Mg, K, Na = 2000 µg/L
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 100 µg/L
Pb = 50 µg/L
Be, Se = 10 µg/L
Sb, Cd, Ag   = 5 µg/L
Tl = 2.5 µg/L

Analysis of Total Metals in Soil by EPA Method 6020

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		MS	MSD		PDS	MS	MSD	
EPA 6020 (mg/kg)	**MRL**	**UDE 1 SED**	**UDE 1 SED**	**RPD %**	**UDE 1 SED**	*Batch 100809-8-1*	*Batch 100809-8-1*	**RPD %**
Date Extracted		8/11/10	8/11/10		8/11/10	8/11/10	8/11/10	
Date Analyzed		8/11/10	8/11/10		8/11/10	8/11/10	8/11/10	
Matrix		Soil	Soil		Soil	Soil	Soil	
Aluminum (Al)	5.5	101%	-	-		128%	129%	1%
Antimony (Sb)	0.20	70%	74%	6%	99%	106%	104%	2%
Arsenic (As)	0.10	151%	174%	14%	94%	100%	105%	5%
Barium (Ba)	0.50	108%	-	-		102%	102%	1%
Beryllium (Be)	0.20	103%	110%	7%		92%	95%	3%
Cadmium (Cd)	0.05	132%	164%	21%	91%	105%	104%	1%
Calcium (Ca)	10	-	-	-	-	112%	108%	4%
Chromium (Cr)	0.10	130%	150%	14%	79%	104%	100%	3%
Cobalt (Co)	0.20	122%	142%	15%	89%	105%	106%	1%
Copper (Cu)	0.10	-		-	95%	105%	110%	4%
Iron (Fe)	5.5	-	-	-	-	118%	96%	21%
Lead (Pb)	0.50	125%	-	-	108%	104%	106%	1%
Magnesium (Mg)	10	-	187%	-	85%	119%	126%	6%
Manganese (Mn)	0.20	-	-	-	93%	117%	116%	1%
Nickel (Ni)	0.10	120%	132%	9%	91%	106%	105%	0.3%
Potassium (K)	50	47%	69%	37%	97%	104%	125%	18%
Selenium (Se)	0.50	104%	108%	4%		114%	109%	4%
Silver (Ag)	0.10	136%	118%	14%	89%	99%	101%	2%
Sodium (Na)*	10	106%	127%	18%		96%	112%	15%
Thallium (Tl)	0.20	128%	157%	20%	84%	105%	107%	2%
Vanadium (V)	0.10	96%	94%	2%	89%	97%	89%	8%
Zinc (Zn)	0.40	-	-	-	-	104%	116%	11%

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
Al, Ca, Fe, Mg, K, Na = 2000 µg/L
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 100 µg/L
Pb = 50 µg/L
Be, Se = 10 µg/L
Sb, Cd, Ag   = 5 µg/L
Tl = 2.5 µg/L

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Mercury in Soil by EPA Method 7471A

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7471A (CVAA) (mg/kg)	**MRL**	**Method Blank**	**LCS**	**UDE 2 SED**	**BSB 1 SED**	**BSB 2 SED**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10	8/11/10
Matrix					Soil	Soil
Mercury (Hg)	0.005	nd	92%	**0.132**	nd	nd

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"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
Spike Concentration:
Hg = 0.4 mg/kg

Mercury in Soil by EPA Method 7471A

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

							Duplicate
EPA 7471A (CVAA) (mg/kg)	**MRL**	**DE 2 SED**	**DE 1 SED**	**MSB 1 SED**	**MSB 2 SED**	**UDE 1 SED**	**UDE 1 SED**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Soil	Soil	Soil	Soil	Soil	Soil
Mercury (Hg)	0.005	nd	nd	**0.126**	nd	nd	nd

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"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
Spike Concentration:
Hg = 0.4 mg/kg

Mercury in Soil by EPA Method 7471A

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		MS	MSD	
EPA 7471A (CVAA) (mg/kg)	**MRL**	**UDE 1 SED**	**UDE 1 SED**	**RPD %**
Date Extracted		8/10/10	8/10/10	
Date Analyzed		8/11/10	8/11/10	
Matrix		Soil	Soil	
Mercury (Hg)	0.005	98%	109%	10%

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
Spike Concentration:
Hg = 0.4 mg/kg

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MRL**	**Method Blank**	**LCS**	**BSB1 PW AM**	**BSB1 PW PM**	**DE2 PW PM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Matrix				Water	Water	Water
Aluminum (Al)	55	nd	106%	**140**	nd	nd
Antimony (Sb)	0.20	nd	111%	**83.7**	**88.5**	**369**
Arsenic (As)	1.0	nd	88.6%	**2.46**	nd	nd
Barium (Ba)	0.30	nd	102%	**154**	**146**	**173**
Beryllium (Be)	0.20	nd	95.2%	nd	nd	nd
Cadmium (Cd)	0.20	nd	105%	**0.578**	**0.345**	nd
Calcium (Ca)	100	nd	111%	**39,100**	**37,600**	**70,000**
Chromium (Cr)	0.60	nd	105%	**2.16**	**2.05**	**2.05**
Cobalt (Co)	0.30	nd	117%	**0.189**	nd	nd
Copper (Cu)	0.40	nd	109%	**50.5**	**8.55**	**16.7**
Iron (Fe)	100	nd	114%	**2100**	nd	**303**
Lead (Pb)	0.20	nd	117%	**30.3**	nd	**0.685**
Magnesium (Mg)	100	nd	107%	**6500**	**5160**	**8410**
Manganese (Mn)	1.0	nd	100%	**37.4**	**8.11**	**2.44**
Nickel (Ni)	0.50	nd	110%	**0.573**	nd	nd
Selenium (Se)	1.0	nd	93.3%	**3.79**	nd	nd
Silver (Ag)	0.20	nd	101%	nd	nd	nd
Sodium (Na)	100	nd	111%	**2800**	**2930**	**2410**
Thallium (Tl)	0.20	nd	122%	**0.221**	nd	nd
Vanadium (V)	0.50	nd	95.8%	nd	**0.582**	nd
Zinc (Zn)	1.5	nd	81.9%	**263**	**109**	**77.5**

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
- LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
- As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
- Al, Ca, Fe, Mg, Na = 11,250 µg/L
- Sb, Be, Cd, Ag = 50 µg/L
- Se = 125 µg/L
- Pb = 500 µg/L
- Tl = 25 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	**DE1 PW AM**	**Rinsate Blank 2**	**Rinsate Blank 1**	**DE1 PW PM**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10
Matrix	Water	Water	Water	Water
Aluminum (Al)	nd	nd	nd	nd
Antimony (Sb)	**12.1**	nd	nd	**10.4**
Arsenic (As)	nd	nd	nd	nd
Barium (Ba)	**115**	**6.49**	**5.2**	**117**
Beryllium (Be)	nd	nd	nd	nd
Cadmium (Cd)	nd	nd	nd	nd
Calcium (Ca)	**53,100**	**2260**	**2400**	**61,700**
Chromium (Cr)	**2.34**	**1.70**	**1.27**	**1.16**
Cobalt (Co)	nd	nd	**0.411**	nd
Copper (Cu)	**3.97**	**4.15**	**4.43**	**4.27**
Iron (Fe)	nd	nd	nd	**128**
Lead (Pb)	nd	nd	nd	nd
Magnesium (Mg)	**8480**	nd	nd	**9710**
Manganese (Mn)	nd	nd	nd	nd
Nickel (Ni)	nd	nd	nd	nd
Selenium (Se)	nd	**1.04**	**3.40**	nd
Silver (Ag)	nd	nd	nd	nd
Sodium (Na)	**2180**	**1240**	**1240**	**2240**
Thallium (Tl)	nd	nd	nd	nd
Vanadium (V)	**0.694**	**0.642**	nd	nd
Zinc (Zn)	**58.4**	**7.54**	**8.71**	**79.7**

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"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**DE2 PW AM**	**MSB 2 PW AM**	**MSB 2 PW PM**	**MSB 1 PW PM**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10
Matrix	Water	Water	Water	Water
Aluminum (Al)	**71.1**	**259**	nd	nd
Antimony (Sb)	**409**	**9.99**	**12.2**	**13.1**
Arsenic (As)	**1.81**	nd	nd	**2.45**
Barium (Ba)	**128.8**	**47.1**	**44.0**	**38.5**
Beryllium (Be)	nd	nd	nd	nd
Cadmium (Cd)	nd	nd	nd	nd
Calcium (Ca)	**53,800**	**33,100**	**32,800**	**28,500**
Chromium (Cr)	**0.938**	**1.01**	**0.685**	**0.763**
Cobalt (Co)	nd	nd	nd	nd
Copper (Cu)	**19.7**	**5.25**	**5.32**	**1.58**
Iron (Fe)	**100**	**727**	nd	**29.0**
Lead (Pb)	nd	**8.41**	**0.915**	nd
Magnesium (Mg)	**7710**	**6760**	**5330**	**6920**
Manganese (Mn)	nd	**20.2**	nd	nd
Nickel (Ni)	nd	nd	nd	nd
Selenium (Se)	nd	nd	nd	nd
Silver (Ag)	nd	nd	nd	nd
Sodium (Na)	**2210**	**2350**	**1690**	**2100**
Thallium (Tl)	nd	nd	nd	nd
Vanadium (V)	nd	**0.794**	nd	nd
Zinc (Zn)	**63.8**	**153**	**77.7**	**32.3**

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"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	**MSB 1 PW AM**	Duplicate **MSB 1 PW AM**	**RPD %**	**UDE-PW-02 PM**	**UDE-PW-02 AM**
Date Extracted	8/10/10	8/10/10		8/10/10	8/10/10
Date Analyzed	8/10/10	8/10/10		8/10/10	8/10/10
Matrix	Water	Water		Water	Water
Aluminum (Al)	**45.4**	**43.1**	5%	**169**	nd
Antimony (Sb)	**14.5**	**14.8**	2%	**2.04**	**1.88**
Arsenic (As)	**1.31**	**2.30**	55%	**nd**	nd
Barium (Ba)	**39.8**	**38.8**	3%	**129**	**109**
Beryllium (Be)	nd	nd		nd	nd
Cadmium (Cd)	nd	nd		nd	nd
Calcium (Ca)	**28,400**	**28,300**	0.1%	**31,300**	**29,300**
Chromium (Cr)	**2.27**	**2.64**	15%	**1.41**	**2.63**
Cobalt (Co)	**0.420**	**0.850**	68%	nd	nd
Copper (Cu)	**4.01**	**8.04**	67%	**13.7**	**7.53**
Iron (Fe)	**370**	**326**	13%	**1060**	**41.3**
Lead (Pb)	**4.95**	**4.16**	17%	**11.0**	nd
Magnesium (Mg)	**6960**	**7130**	2%	**9690**	**7550**
Manganese (Mn)	**3.48**	**4.04**	15%	**23.6**	nd
Nickel (Ni)	nd	nd		nd	nd
Selenium (Se)	nd	nd		nd	nd
Silver (Ag)	nd	nd		nd	nd
Sodium (Na)	**2510**	**2340**	7%	**2070**	**1960**
Thallium (Tl)	nd	nd		nd	nd
Vanadium (V)	nd	nd		nd	nd
Zinc (Zn)	**70.7**	**51.3**	32%	**118**	**40.5**

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"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**UDE-PW-01 AM**	**UDE-1 PW PM**	**Rinsate Blank 3**	**Rinsate Blank 4**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10
Matrix	Water	Water	Water	Water
Aluminum (Al)	**26.5**	nd	nd	nd
Antimony (Sb)	**2.60**	**3.02**	nd	nd
Arsenic (As)	nd	nd	nd	nd
Barium (Ba)	**28.6**	**28.6**	**5.61**	**5.29**
Beryllium (Be)	nd	nd	nd	nd
Cadmium (Cd)	nd	nd	nd	nd
Calcium (Ca)	**27,200**	**28,800**	nd	nd
Chromium (Cr)	**2.33**	**1.48**	**1.71**	**1.45**
Cobalt (Co)	nd	nd	nd	nd
Copper (Cu)	**12.8**	**4.50**	**8.16**	**3.50**
Iron (Fe)	**447**	**284**	nd	nd
Lead (Pb)	**2.95**	nd	nd	nd
Magnesium (Mg)	**5790**	**5940**	nd	nd
Manganese (Mn)	**6.53**	**2.88**	nd	nd
Nickel (Ni)	nd	nd	nd	nd
Selenium (Se)	nd	nd	nd	nd
Silver (Ag)	nd	**1.19**	nd	nd
Sodium (Na)	**1790**	**2100**	**310**	**1520**
Thallium (Tl)	nd	nd	nd	nd
Vanadium (V)	**0.83**	**0.639**	**0.460**	nd
Zinc (Zn)	**63.2**	**17.5**	**0.965**	nd

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Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

			MS	MSD	
EPA 200.8 (ug/L)	**BSB 2 PW AM**	**BSB 2 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**	**RPD %**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10	
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10	
Matrix	Water	Water	Water	Water	
Aluminum (Al)	nd	**1560**	115%	111%	4%
Antimony (Sb)	**15.7**	**18.2**	118%	110%	7%
Arsenic (As)	nd	nd	93%	87%	7%
Barium (Ba)	**73.4**	**212**	113%	105%	7%
Beryllium (Be)	nd	nd	108%	102%	5%
Cadmium (Cd)	nd	nd	115%	108%	6%
Calcium (Ca)	**19,600**	**28,200**	94%	80%	16%
Chromium (Cr)	**3.05**	**7.62**	115%	110%	4%
Cobalt (Co)	nd	**3.09**	126%	118%	7%
Copper (Cu)	**22.2**	**101**	125%	113%	10%
Iron (Fe)	**130**	**15,400**	134%	119%	12%
Lead (Pb)	**5.72**	**18.8**	128%	121%	6%
Magnesium (Mg)	**4270**	**6290**	107%	90%	17%
Manganese (Mn)	nd	**366**	94%	94%	0%
Nickel (Ni)	nd	nd	101%	107%	6%
Selenium (Se)	nd	nd	100%	91%	9%
Silver (Ag)	nd	nd	109%	103%	6%
Sodium (Na)	**1780**	**2290**	123%	107%	14%
Thallium (Tl)	nd	nd	131%	124%	5%
Vanadium (V)	nd	nd	108%	102%	6%
Zinc (Zn)	**29.8**	**1070**	80%	82%	2%

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"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%

Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	**MRL**	**Method Blank**	**LCS**	**BSB1 PW AM**	**BSB1 PW PM**	**DE2 PW PM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/12/10	8/12/10	8/12/10	8/12/10	8/12/10
Matrix				Water	Water	Water
Potassium (K)	500	nd	89%	**3445**	**3960**	**7850**

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"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
K = 11,250 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	**DE1 PW AM**	**Rinsate Blank 2**	**Rinsate Blank 1**	**DE1 PW PM**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/12/10	8/12/10	8/12/10	8/12/10
Matrix	Water	Water	Water	Water
Potassium (K)	**5790**	**2970**	**4100**	**6690**

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
K = 11,250 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**DE2 PW AM**	**MSB 2 PW AM**	**MSB 2 PW PM**	**MSB 1 PW PM**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/12/10	8/12/10	8/12/10	8/12/10
Matrix	Water	Water	Water	Water
Potassium (K)	**5340**	**10,100**	**7000**	**7490**

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"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
K = 11,250 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	**MSB 1 PW AM**	Duplicate **MSB 1 PW AM**	**RPD %**	**UDE-PW-02 PM**	**UDE-PW-02 AM**
Date Extracted	8/10/10	8/10/10		8/10/10	8/10/10
Date Analyzed	8/12/10	8/12/10		8/12/10	8/12/10
Matrix	Water	Water		Water	Water
Potassium (K)	**5440**	**5760**	6%	**10,500**	**10,500**

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"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
K = 11,250 µg/L

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Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**UDE-PW-01 AM**	**UDE-1 PW PM**	**Rinsate Blank 3**	**Rinsate Blank 3**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/12/10	8/12/10	8/10/10	8/10/10
Matrix	Water	Water	Water	Water
Potassium (K)	**10,600**	**11,400**	**10,800**	**10,200**

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
K = 11,250 µg/L

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

			MS	MSD	
EPA 200.8 (ug/L)	**BSB 2 PW AM**	**BSB 2 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**	**RPD %**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10	
Date Analyzed	8/12/10	8/12/10	8/12/10	8/12/10	
Matrix	Water	Water	Water	Water	
Potassium (K)	**10,500**	**11,800**	110%	113%	2%

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"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
K = 11,250 µg/L

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MRL**	**Method Blank**	**LCS**	**BSB1 PW AM**	**BSB1 PW PM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10
Matrix				Water	Water
Aluminum (Al)	55	nd	90.8%	nd	nd
Antimony (Sb)	0.20	nd	90.3%	**71.1**	**76.7**
Arsenic (As)	1.0	nd	96.4%	nd	nd
Barium (Ba)	0.30	nd	89.0%	**113**	**127**
Beryllium (Be)	0.20	nd	112.0%	**1.33**	**1.32**
Cadmium (Cd)	0.20	nd	98.0%	**0.442**	**0.438**
Calcium (Ca)	100	nd	95.3%	**34,500**	**35,200**
Chromium (Cr)	0.60	**0.970**	94.5%	**3.47**	**2.41**
Cobalt (Co)	0.30	nd	110.0%	**0.375**	nd
Copper (Cu)	0.40	nd	110.0%	**10.7**	**8.98**
Iron (Fe)	100	nd	98.8%	**116**	nd
Lead (Pb)	0.20	nd	101.0%	**2.96**	**2.81**
Magnesium (Mg)	100	nd	90.4%	**4590**	**4880**
Manganese (Mn)	1.0	nd	93.5%	**8.48**	**11.8**
Nickel (Ni)	0.50	nd	106.0%	**0.748**	nd
Potassium (K)	500	nd	113.6%	**3050**	**5980**
Selenium (Se)	1.0	nd	102.0%	nd	nd
Silver (Ag)	0.20	nd	88.7%	nd	nd
Sodium (Na)	100	nd	103.4%	**2290**	**2490**
Thallium (Tl)	0.20	nd	106.0%	nd	nd
Vanadium (V)	0.50	nd	90.2%	**1.92**	**1.54**
Zinc (Zn)	1.5	nd	99.3%	**155**	**153**

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Acceptable Recovery Limits:
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Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, K, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	**DE2 PW PM**	**DE1 PW AM**	**DE1 PW PM**	**DE2 PW AM**	**MSB 2 PW AM**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Matrix	Water	Water	Water	Water	Water
Aluminum (Al)	nd	**694**	nd	nd	nd
Antimony (Sb)	**344**	**11.7**	**9.58**	**352**	**9.56**
Arsenic (As)	**1.97**	**1.08**	nd	**1.48**	nd
Barium (Ba)	**149**	**135**	**103**	**112**	**39.1**
Beryllium (Be)	**1.62**	**1.28**	**0.852**	**0.491**	**1.27**
Cadmium (Cd)	**0.251**	**0.643**	nd	nd	nd
Calcium (Ca)	**69,400**	**54,100**	**52,800**	**46,800**	**29,300**
Chromium (Cr)	**3.56**	**6.74**	**3.79**	**2.56**	**2.62**
Cobalt (Co)	nd	**1.15**	nd	nd	nd
Copper (Cu)	**14.4**	**47.4**	**7.35**	**12.9**	**10.5**
Iron (Fe)	nd	**6730**	**134**	nd	nd
Lead (Pb)	**2.59**	**32**	**2.69**	**2.62**	**3.90**
Magnesium (Mg)	**9800**	**10,200**	**9210**	**6360**	**4950**
Manganese (Mn)	nd	**153**	nd	nd	nd
Nickel (Ni)	nd	**0.612**	nd	nd	**0.588**
Potassium (K)	**7290**	**7880**	**5490**	**6440**	**5390**
Selenium (Se)	nd	**3.58**	nd	nd	nd
Silver (Ag)	nd	nd	nd	nd	nd
Sodium (Na)	**3920**	**2000**	**2040**	**2040**	**1550**
Thallium (Tl)	nd	nd	nd	nd	nd
Vanadium (V)	**1.48**	nd	**1.41**	**1.20**	**0.840**
Zinc (Zn)	**100**	**630**	**79.8**	**58.8**	**79.6**

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Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, K, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MSB 2 PW PM**	**MSB 1 PW PM**	**MSB 1 PW AM**	Duplicate **MSB 1 PW AM**	**RPD** **%**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10	
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10	
Matrix	Water	Water	Water	Water	
Aluminum (Al)	nd	nd	nd	nd	
Antimony (Sb)	**9.33**	**11.1**	**11.4**	**12**	1%
Arsenic (As)	nd	**2.51**	**2.16**	**3.2**	10%
Barium (Ba)	**36.8**	**33.8**	**30.0**	**32**	2%
Beryllium (Be)	**1.34**	**1.31**	**1.28**	**1.6**	6%
Cadmium (Cd)	nd	nd	nd	nd	
Calcium (Ca)	**29,100**	**27,500**	**23,000**	**24850**	2%
Chromium (Cr)	**2.45**	**2.58**	**2.27**	**3.4**	10%
Cobalt (Co)	nd	nd	nd	**0.578**	-
Copper (Cu)	**1.62**	**5.78**	**3.47**	**2.8**	6%
Iron (Fe)	nd	nd	nd	**48**	
Lead (Pb)	**2.65**	**3.01**	**3.36**	**3.25**	1%
Magnesium (Mg)	**4870**	**7000**	**5550**	**6405**	4%
Manganese (Mn)	nd	nd	**0.605 J**	**1.42**	20%
Nickel (Ni)	nd	nd	nd	nd	
Potassium (K)	**3880**	**2580**	**8420**	**5860**	9%
Selenium (Se)	nd	nd	nd	nd	
Silver (Ag)	nd	nd	nd	nd	
Sodium (Na)	**1520**	**2150**	**1770**	**2010**	3%
Thallium (Tl)	nd	nd	nd	nd	
Vanadium (V)	**0.540**	**0.948**	**0.993**	**2.0**	17%
Zinc (Zn)	**76.6**	**27.6**	**27.7**	**27**	1%

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, K, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	**UDE-PW-02 PM**	**UDE-PW-02 AM**	**UDE-PW-01 AM**	**UDE-1 PW PM**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10
Matrix	Water	Water	Water	Water
Aluminum (Al)	nd	nd	nd	nd
Antimony (Sb)	**1.66**	**1.46**	**2.13**	**2.6**
Arsenic (As)	nd	nd	nd	nd
Barium (Ba)	**95.4**	**100**	**23.9**	**23.3**
Beryllium (Be)	**2.00**	**1.54**	**9.59**	**0.785**
Cadmium (Cd)	nd	nd	nd	nd
Calcium (Ca)	**28,500**	**28,900**	**25,300**	**27,700**
Chromium (Cr)	**3.42**	**2.52**	**2.59**	**2.83**
Cobalt (Co)	nd	nd	nd	nd
Copper (Cu)	**4.00**	**4.88**	**5.46**	**6.6**
Iron (Fe)	nd	nd	nd	nd
Lead (Pb)	**2.54**	**2.65**	**2.37**	**2.9**
Magnesium (Mg)	**7960**	**8440**	**6140**	**6300**
Manganese (Mn)	nd	nd	nd	nd
Nickel (Ni)	nd	nd	nd	nd
Potassium (K)	**7190**	**3760**	**4330**	**2740**
Selenium (Se)	nd	nd	nd	nd
Silver (Ag)	nd	nd	nd	nd
Sodium (Na)	**1770**	**361**	**383**	**378**
Thallium (Tl)	nd	nd	nd	nd
Vanadium (V)	**1.03**	**0.874**	**1.04**	**1.06**
Zinc (Zn)	**43.7**	**46.7**	**3.78**	**6.63**

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, K, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

			MS	MSD	
EPA 200.8 (ug/L)	**BSB 2 PW AM**	**BSB 2 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**	**RPD %**
Date Extracted	8/10/10	8/10/10	8/10/10	8/10/10	
Date Analyzed	8/10/10	8/10/10	8/10/10	8/10/10	
Matrix	Water	Water	Water	Water	
Aluminum (Al)	nd	nd	116%	100%	15%
Antimony (Sb)	**13.6**	**8.18**	111%	96%	14%
Arsenic (As)	nd	nd	90%	93%	3%
Barium (Ba)	**58.2**	**54.8**	94%	87%	8%
Beryllium (Be)	**0.390**	**0.335**	115%	113%	2%
Cadmium (Cd)	nd	nd	106%	97%	9%
Calcium (Ca)	**18,800**	**17,400**	183%	101%	58%
Chromium (Cr)	**1.95**	**2.14**	98%	93%	5%
Cobalt (Co)	nd	nd	99%	100%	1%
Copper (Cu)	**4.14**	**6.17**	99%	92%	7%
Iron (Fe)	**141**	nd	91%	96%	5%
Lead (Pb)	**2.93**	**2.35**	103%	100%	3%
Magnesium (Mg)	**4430**	**4100**	140%	105%	29%
Manganese (Mn)	**2.10**	nd	97%	106%	9%
Nickel (Ni)	nd	nd	98%	90%	9%
Potassium (K)	**1410**	**3420**	131%	167%	24%
Selenium (Se)	nd	nd	87%	76%	13%
Silver (Ag)	nd	nd	99%	91%	8%
Sodium (Na)	**1810**	**320**	131%	108%	19%
Thallium (Tl)	nd	nd	110%	107%	3%
Vanadium (V)	nd	nd	93%	86%	8%
Zinc (Zn)	**46.3**	**21.9**	84%	111%	28%

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
As, Ba, Cr, Co, Cu, Mn, Ni, V, Zn = 1000 µg/L
Al, Ca, Fe, Mg, K, Na = 11,250 µg/L
Sb, Be, Cd, Ag = 50 µg/L
Se = 125 µg/L
Pb = 500 µg/L
Tl = 25 µg/L

Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (µg/L)	**MRL**	**Method Blank**	**LCS**	**BSB1 PW AM**	**BSB1 PW PM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10
Matrix				Water	Water
Mercury (Hg)	0.00005	nd	98%	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (µg/L)	**MRL**	**DE2 PW PM**	**DE1 PW AM**	**Rinsate Blank 2**	**Rinsate Blank 1**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (µg/L)	**MRL**	**DE1 PW PM**	**DE2 PW AM**	**UDE 2 SED**	**MSB 2 PW AM**	**MSB 2 PW PM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%

LCS Concentration:
Hg = 20 ng/L

Spike Concentration:
Hg = 20 ng/L

Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

				Duplicate	
EPA 7470 (CVAA) (µg/L)	**MRL**	**MSB 1 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**	**UDE-PW-02 PM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (µg/L)	**MRL**	**UDE-PW-02 AM**	**UDE-PW-01 AM**	**UDE-1 PW PM**	**Rinsate Blank 3**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (µg/L)	**MRL**	**Rinsate Blank 4**	**BSB 2 PW AM**	**BSB 2 PW PM**
Date Extracted		8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

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Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		MS	MSD	
EPA 7470 (CVAA) (µg/L)	**MRL**	**MSB 1 PW AM**	**MSB 1 PW AM**	**RPD %**
Date Extracted		8/10/10	8/10/10	
Date Analyzed		8/11/10	8/11/10	
Matrix		Water	Water	
Mercury (Hg)	0.00005	78%	79%	1%

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Dissolved Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (µg/L)	MRL	Method Blank	LCS	BSB1 PW AM	BSB1 PW PM
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10
Matrix				Water	Water
Mercury (Hg)	0.00005	nd	105%	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Dissolved Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (µg/L)	**MRL**	**DE2 PW PM**	**DE1 PW AM**	**DE1 PW PM**	**DE2 PW AM**	**MSB 2 PW AM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Dissolved Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

					Duplicate
EPA 7470 (CVAA) (µg/L)	**MRL**	**MSB 2 PW PM**	**MSB 1 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Dissolved Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 7470 (CVAA) (μg/L)	MRL	UDE-PW-02 PM	UDE-PW-02 AM	UDE-PW-01 AM	UDE-1 PW PM
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10
Matrix		Water	Water	Water	Water
Mercury (Hg)	0.00005	nd	nd	nd	nd

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Dissolved Mercury in Water by EPA Method 7470

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

				MS	MSD	
EPA 7470 (CVAA) (µg/L)	**MRL**	**BSB 2 PW AM**	**BSB 2 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**	**RPD %**
Date Extracted		8/10/10	8/10/10	8/10/10	8/10/10	
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10	
Matrix		Water	Water	Water	Water	
Mercury (Hg)	0.00005	nd	nd	116%	104%	10%

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 70% to 130%
LCS Concentration:
Hg = 20 ng/L
Spike Concentration:
Hg = 20 ng/L

Dissolved Silica by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (µg/L)	**MRL**	**Method Blank**	**LCS**	**BSB1 PW AM**	**BSB1 PW PM**	**DE2 PW PM**
Date Extracted		8/12/10	8/12/10	8/12/10	8/12/10	8/12/10
Date Analyzed		8/12/10	8/12/10	8/12/10	8/12/10	8/12/10
Matrix				Water	Water	Water
Silicon	*500*	*nd*	*102%*	*1801*	*2090*	*2774*
Silica (Calculated from Si)				**3850**	**4470**	**5940**

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
Si = 5 mg/L

Dissolved Silica by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (µg/L)	**MRL**	**DE1 PW AM**	**DE1 PW PM**	**DE2 PW AM**	**MSB 2 PW AM**	**MSB 2 PW PM**
Date Extracted		8/12/10	8/12/10	8/12/10	8/12/10	8/12/10
Date Analyzed		8/12/10	8/12/10	8/12/10	8/12/10	8/12/10
Matrix		Water	Water	Water	Water	Water
Silicon	*500*	*3264*	*3630*	*1958*	*2462*	*2296*
Silica (Calculated from Si)		**6980**	**7770**	**4190**	**5270**	**4910**

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
Si = 5 mg/L

Dissolved Silica by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (µg/L)	**MRL**	**MSB 1 PW PM**	**MSB 1 PW AM**	Duplicate **MSB 1 PW AM**	**RPD %**	**UDE-PW-02 PM**
Date Extracted		8/12/10	8/12/10	8/12/10		8/12/10
Date Analyzed		8/12/10	8/12/10	8/12/10		8/12/10
Matrix		Water	Water	Water		Water
Silicon	*500*	*2714*	*2040*	*2372.0*	*15%*	*4164*
Silica (Calculated from Si)		**5810**	**4370**	**5080**	15%	**8910**

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
Si = 5 mg/L

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Dissolved Silica by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (µg/L)	**MRL**	**UDE-PW-02 AM**	**UDE-PW-01 AM**	**UDE-1 PW PM**	**BSB 2 PW AM**
Date Extracted		8/12/10	8/12/10	8/12/10	8/12/10
Date Analyzed		8/12/10	8/12/10	8/12/10	8/12/10
Matrix		Water	Water	Water	Water
Silicon	*500*	*3412*	*1383*	*1653*	*1427*
Silica (Calculated from Si)		**7300**	**2960**	**3540**	**3050**

"nd" Indicates no detection at the listed reporting limits
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"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
Si = 5 mg/L

Dissolved Silica by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

			MS	MSD	
EPA 200.8 (µg/L)	**MRL**	**BSB 2 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**	**RPD %**
Date Extracted		8/12/10	8/12/10	8/12/10	
Date Analyzed		8/12/10	8/12/10	8/12/10	
Matrix		Water	Water	Water	
Silicon	*500*	*1064*	*108%*	*103%*	*5%*
Silica (Calculated from Si)		**2280**			

"nd" Indicates no detection at the listed reporting limits
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"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 20%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 75%-125%
Spike Concentration:
Si = 5 mg/L

Ion Chromatography by EPA Method 300.0

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA Method 300.0 (mg/L)	**MRL**		**Method Blank**	**LCS**	**CCV**	**BSB1 PW AM**	**BSB1 PW PM**
Date Analyzed			8/9/10	8/9/10	8/9/10	8/9/10	8/9/10
Matrix						Water	Water
Bromide (Br)	0.1		nd	106%	103%	nd	nd
Chloride (Cl)	0.1		nd	109%	105%	**1.36**	**1.31**
Fluoride (F)	0.1		nd	106%	104%	**0.352**	**0.414**
Nitrate (NO_3)	0.1	H	nd	108%	102%	**0.208**	**0.294**
Nitrite (NO_2)	0.1	H	nd	105%	101%	nd	nd
Phosphate (PO_4)	0.1	H	nd	116%	120%	nd	nd
Sulfate (SO_4)	0.1		nd	109%	100%	**19.8**	**19.3**

"nd" Indicates no detection at the listed reporting limits
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"J" Indicates estimated value
"H" Indicates exceeded holding time
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"CCV" Indicates Continuing Calibration Verification
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentrations:
F = 1.0 mg/L
Cl = 1.5 mg/L
NO_2 = 1.5 mg/L
Br = 5.0 mg/L
NO_3 = 1.0 mg/L
PO_4 = 2.5 mg/L
SO_4 = 7.5 mg/L

Ion Chromatography by EPA Method 300.0

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA Method 300.0 (mg/L)	**MRL**		**DE2 PW PM**	**DE1 PW AM**	**DE1 PW PM**	**DE2 PW AM**	**MSB 2 PW AM**
Date Analyzed			8/9/10	8/9/10	8/9/10	8/9/10	8/9/10
Matrix			Water	Water	Water	Water	Water
Bromide (Br)	0.1		nd	nd	nd	nd	nd
Chloride (Cl)	0.1		**0.903**	**0.590**	**0.706**	**0.917**	**0.833**
Fluoride (F)	0.1		**0.412**	**0.439**	**0.395**	**0.456**	**0.545**
Nitrate (NO_3)	0.1	H	**2.47**	**2.03**	**1.27**	**1.73**	**1.19**
Nitrite (NO_2)	0.1	H	nd	nd	nd	nd	nd
Phosphate (PO_4)	0.1	H	nd	nd	nd	nd	nd
Sulfate (SO_4)	0.1		**101**	**41.8**	**46.9**	**46.3**	**20.6**

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"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"CCV" Indicates Continuing Calibration Verification
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%

Spike Concentrations:
F = 1.0 mg/L
Cl = 1.5 mg/L
NO_2 = 1.5 mg/L
Br = 5.0 mg/L
NO_3 = 1.0 mg/L
PO_4 = 2.5 mg/L
SO_4 = 7.5 mg/L

Ion Chromatography by EPA Method 300.0

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

						Duplicate	
EPA Method 300.0 (mg/L)	**MRL**		**MSB 2 PW PM**	**MSB 1 PW PM**	**MSB 1 PW AM**	**MSB 1 PW AM**	**RPD %**
Date Analyzed			8/9/10	8/9/10	8/9/10	8/9/10	
Matrix			Water	Water	Water	Water	
Bromide (Br)	0.1		nd	nd	nd	nd	
Chloride (Cl)	0.1		**0.890**	**0.879**	**0.825**	**0.798**	3%
Fluoride (F)	0.1		**0.502**	**0.525**	**0.533**	**0.594**	11%
Nitrate (NO_3)	0.1	H	**0.551**	**0.348**	**0.318**	**0.313**	2%
Nitrite (NO_2)	0.1	H	nd	nd	nd	nd	
Phosphate (PO_4)	0.1	H	nd	nd	nd	nd	
Sulfate (SO_4)	0.1		**17.2**	**13.1**	**12.2**	**12.3**	0.2%

"nd" Indicates no detection at the listed reporting limits
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"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"CCV" Indicates Continuing Calibration Verification
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentrations:
F = 1.0 mg/L
Cl = 1.5 mg/L
NO_2 = 1.5 mg/L
Br = 5.0 mg/L
NO_3 = 1.0 mg/L
PO_4 = 2.5 mg/L
SO_4 = 7.5 mg/L

Ion Chromatography by EPA Method 300.0

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA Method 300.0 (mg/L)	**MRL**		**UDE-PW-02 PM**	**UDE-PW-02 AM**	**UDE-PW-01 AM**	**UDE-1 PW PM**
Date Analyzed			8/9/10	8/9/10	8/9/10	8/9/10
Matrix			Water	Water	Water	Water
Bromide (Br)	0.1		nd	nd	nd	nd
Chloride (Cl)	0.1		**0.787**	**0.793**	**0.760**	**0.823**
Fluoride (F)	0.1		**0.308**	**0.250**	**0.313**	**0.246**
Nitrate (NO_3)	0.1	H	nd	**0.176**	**0.222**	**0.212**
Nitrite (NO_2)	0.1	H	nd	nd	nd	nd
Phosphate (PO_4)	0.1	H	nd	nd	nd	nd
Sulfate (SO_4)	0.1		**12.5**	**12.6**	**13.4**	**12.4**

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"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%

Spike Concentrations:
F = 1.0 mg/L
Cl = 1.5 mg/L
NO_2 = 1.5 mg/L
Br = 5.0 mg/L
NO_3 = 1.0 mg/L
PO_4 = 2.5 mg/L
SO_4 = 7.5 mg/L

Ion Chromatography by EPA Method 300.0

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA Method 300.0 (mg/L)	**MRL**		**BSB 2 PW AM**	**BSB 2 PW PM**	MS **DE2 PW AM**	MSD **DE2 PW AM**	**RPD %**
Date Analyzed			8/9/10	8/10/10	8/9/10	8/9/10	
Matrix			Water	Water	Water	Water	
Bromide (Br)	0.1		nd	nd	107%	109%	2%
Chloride (Cl)	0.1		**0.880**	**0.817**	94.7%	97.1%	2%
Fluoride (F)	0.1		**0.234**	**0.175**	104%	106%	2%
Nitrate (NO_3)	0.1	H	**0.211**	**0.284**	96.9%	99.2%	2%
Nitrite (NO_2)	0.1	H	nd	nd	105%	107%	2%
Phosphate (PO_4)	0.1	H	nd	nd	182%	188%	3%
Sulfate (SO_4)	0.1		**9.60**	**9.30**	113%	114%	2%

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"CCV" Indicates Continuing Calibration Verification
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%

Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%

Spike Concentrations:
F = 1.0 mg/L
Cl = 1.5 mg/L
NO_2 = 1.5 mg/L
Br = 5.0 mg/L
NO_3 = 1.0 mg/L
PO_4 = 2.5 mg/L
SO_4 = 7.5 mg/L

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Total Organic Carbon by EPA Method 9060A

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 9060A *(Percent Organic Carbon by Weight)*	**MRL**	**Method Blank**	**LCS**	**UDE 2 SED**	**BSB 1 SED**	**BSB 2 SED**	**DE 2 SED**
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10	8/11/10	8/11/10
Matrix				Soil	Soil	Soil	Soil
Total Organic Carbon	0.15	nd	96%	**0.925**	**0.420**	**0.160**	nd

"nd" Indicates no detection at the listed reporting limits
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"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 0.05 % by Weight (gm)

Total Organic Carbon by EPA Method 9060A

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

						Duplicate	
EPA 9060A	**MRL**	**DE 1 SED**	**MSB 1 SED**	**MSB 2 SED**	**UDE 1 SED**	**UDE 1 SED**	**RPD**
(Percent Organic Carbon by Weight)							**%**
Date Analyzed		8/11/10	8/11/10	8/11/10	8/11/10	8/11/10	
Matrix		Soil	Soil	Soil	Soil	Soil	
Total Organic Carbon	0.15	nd	**0.163**	nd	**0.521**	**0.554**	6%

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"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 0.05 % by Weight (gm)

Total Organic Carbon by EPA Method 9060A

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		MS	MSD	
EPA 9060A	**MRL**	**UDE 1 SED**	**UDE 1 SED**	**RPD**
(Percent Organic Carbon by Weight)				**%**
Date Analyzed		8/11/10	8/11/10	
Matrix		Soil	Soil	
Total Organic Carbon	0.15	67%	69%	4%

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
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"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 0.05 % by Weight (gm)

Total Organic Carbon by SM 5310B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 5310B (mg/L)	**MRL**	**Method Blank**	**LCS**	**BSB1 PW AM**	**BSB1 PW PM**	**DE2 PW PM**
Date Analyzed		8/9/10	8/9/10	8/9/10	8/9/10	8/9/10
Matrix				Water	Water	Water
Total Organic Carbon	0.5	nd	91.8%	**1.05**	**0.968**	**0.937**

"nd" Indicates no detection at the listed reporting limits
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"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 5.0 mg/L

Total Organic Carbon by SM 5310B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 5310B (mg/L)	**MRL**	**DE1 PW AM**	**DE1 PW PM**	**DE2 PW AM**	**MSB 2 PW AM**	**MSB 2 PW PM**
Date Analyzed		8/9/10	8/9/10	8/9/10	8/9/10	8/9/10
Matrix		Water	Water	Water	Water	Water
Total Organic Carbon	0.5	**1.17**	**0.827**	**1.05**	**0.691**	**0.678**

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"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 5.0 mg/L

Total Organic Carbon by SM 5310B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 5310B (mg/L)	**MRL**	**MSB 1 PW PM**	**MSB 1 PW AM**	**UDE-PW-02 PM**	**UDE-PW-02 AM**
Date Analyzed		8/9/10	8/9/10	8/9/10	8/9/10
Matrix		Water	Water	Water	Water
Total Organic Carbon	0.5	**0.810**	**0.742**	**1.07**	**1.07**

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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 5.0 mg/L

Total Organic Carbon by SM 5310B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 5310B (mg/L)	**MRL**	**UDE-PW-01 AM**	**UDE-PW 01 PW**	**BSB 2 PW AM**	Duplicate **BSB 2 PW AM**	**RPD %**
Date Analyzed		8/9/10	8/9/10	8/9/10	8/9/10	
Matrix		Water	Water	Water	Water	
Total Organic Carbon	0.5	**0.856**	**0.919**	**0.906**	**0.884**	3%

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 5.0 mg/L

Total Organic Carbon by SM 5310B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

			MS	MSD	
SM 5310B (mg/L)	**MRL**	**BSB 2 PW PM**	**BSB 2 PW PM**	**BSB 2 PW PM**	**RPD %**
Date Analyzed		8/9/10	8/9/10	8/9/10	
Matrix		Water	Water	Water	
Total Organic Carbon	0.5	**1.02**	79.5%	87.3%	9%

"nd" Indicates no detection at the listed reporting limits
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"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits:
LCS, LCSD, MS, MSD: 65% to 135%
Spike Concentration = 5.0 mg/L

Alkalinity by SM 2320B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 2320B **mg/L $CaCO_3$**	**MRL**	**Method Blank**	**LCS**	**BSB1 PW AM**	**BSB1 PW PM**
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10
Matrix				Water	Water
Total Alkalinity	5.0	nd	95%	**89**	**92**

"nd" Indicates no detection at the listed reporting limits
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"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits: 65% to 135%
Spike Concentration: 100 mg/L

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Alkalinity by SM 2320B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 2320B **mg/L $CaCO_3$**	**MRL**	**DE2 PW PM**	**DE1 PW AM**	**DE1 PW PM**	**DE2 PW AM**	**MSB 2 PW AM**
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10	8/10/10
Matrix		Water	Water	Water	Water	Water
Total Alkalinity	5.0	**110**	**112**	**128**	**104**	**80**

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"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits: 65% to 135%
Spike Concentration: 100 mg/L

Alkalinity by SM 2320B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 2320B mg/L $CaCO_3$	**MRL**	**MSB 2 PW PM**	**MSB 1 PW PM**	**MSB 1 PW AM**	Duplicate **MSB 1 PW AM**	**RPD %**
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10	
Matrix		Water	Water	Water	Water	
Total Alkalinity	5.0	**62**	**86**	**75**	**76**	1%

"nd" Indicates no detection at the listed reporting limits
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"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits: 65% to 135%
Spike Concentration: 100 mg/L

Alkalinity by SM 2320B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

SM 2320B **mg/L $CaCO_3$**	**MRL**	**UDE-PW-02 PM**	**UDE-PW-02 AM**	**UDE-PW-01 AM**	**UDE-1 PW PM**
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10
Matrix		Water	Water	Water	Water
Total Alkalinity	5.0	**96**	**100**	**82**	**84**

"nd" Indicates no detection at the listed reporting limits
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"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits: 65% to 135%
Spike Concentration: 100 mg/L

Alkalinity by SM 2320B

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

				MS	MSD	
SM 2320B mg/L $CaCO_3$	**MRL**	**BSB 2 PW AM**	**BSB 2 PW PM**	**MSB 1 PW PM**	**MSB 1 PW PM**	**RPD %**
Date Analyzed		8/10/10	8/10/10	8/10/10	8/10/10	
Matrix		Water	Water	Water	Water	
Total Alkalinity	5.0	**60**	**58**	106%	108%	2%

"nd" Indicates no detection at the listed reporting limits
"int" Indicates that interference prevents determination
"J" Indicates estimated value
"MRL" Indicates Method Reporting Limit
"LCS" Indicates Laboratory Control Sample
"MS" Indicates Matrix Spike
"MSD" Indicates Matrix Spike Duplicate
"RPD" Indicates Relative Percent Difference

Acceptable RPD is determined to be less than 30%
Acceptable Recovery Limits: 65% to 135%
Spike Concentration: 100 mg/L

Fremont Analytical

Chain of Custody Record

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Date: 8/5/2010

Laboratory Project No (internal): CHm100809-3

Page: 1 of: 1

Client: ENVIRONMENT INTERNATIONAL

Address:

City, State, Zip

Tel:

Project Name: UCR PORewATER

Location:

Collected by:

Reports To (PM):

Fax:

Email:

Project No:

	Sample Name	Time	Sample Type (Matrix)	Container Type	Date of Collection	VOA 8260	VOA 8021B BTEX	NWTPH-Gx	NWTPH-HCID	NWTPH-Dx/Dx Ext.	SEMI VOL 8270C	PAH 8270	PCBs 8082	Cl PESTICIDES 8081	Cl HERBICIDES 8151A	Metals*	Total (T) | Dissolved (D)	Anions (IC)**	TOC	ALKALINITY			Comments/Depth
✓	1 BSB1 PW AM	6:30	H2O	x4	8/4											X	T/D	X	X	X			
✓	2 BSB1 PW PM	4:30P		x5	8/3											X		X	X	X			
✓	3 DE 2 PW PM	5:30P		x4	8/4											X		X	X	X			
✓	4 DE 1 PW AM	6 A		x4	8/5											X		X	X	X			
	5 RINSATE BLANK 2	15:00		x1	8/5											X							
	6 RINSATE BLANK 1	13:00		x1	8/5											X							
✓	7 DE 1 PW PM	16:45		x4	8/4											X		X	X	X			
✓	8 DE 2 PW AM	7:00		x4	8/5											X		X	X	X			
✓	9 UDE 2 SED	11:00		x2	8/5											X			X				
	10 TEMP BLANK																						

*Metals Analysis (Circle): MTCA-5 RCRA-8 Priority Pollutants [✓ TAL] *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl U V Zn

**Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

(*) Si DISSOLVED

Relinquished x	Date/Time 3:30P 8/5/2010	Received	Date/Time 8/9/10 13:44	**Sample Receipt:**	
				Good?	Y
				Cooler Temperature:	9.2
Relinquished x	Date/Time	Received x	Date/Time	Seals Intact?:	N/A
				Total Number of Containers:	29

Special Remarks:

TAT -> 24HR [✓ 48HR] Standard

Distribution: White - Lab, Yellow - File, Pink - Originator

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Fremont Analytical

Chain of Custody Record

2930 Westlake Ave. N. Suite 100
Seattle, WA 98103

Tel: 206-352-3790
Fax: 206-352-7178

Laboratory Project No (internal): CHM100809-4

Date: 8/5/2010

Page: 1 of: 1

Client: ENVIRONMENT INTERNATIONAL

Address: 5505 34th Ave NE

City, State, Zip: Seattle, WA 98105

Tel: 2065253362

Project Name: UCR POREWATER

Location:

Collected by: MARIA BRUMM

Reports To (PM): Whitney Fraser

Fax: 206 525 0869

Email: whitney.fraser@eiltd.net

Project No:

	Sample Name	Time	Sample Type (Matrix)	Container Type	Date of Collection	VOA 8260	VOA 8021B BTEX	NWTPH-Gx	NWTPH-HCID	NWTPH-Dx/Dx Ext.	SEMI VOL 8270C	PAH 8270	PCBs 8082	Cl PESTICIDES 8081	Cl HERBICIDES 8151A	Metals*	Total (T) / [✓ Dissolved (D)]	Anions (IC)**	TOC	ALKALINITY			Comments/Depth
1	MSB 2 PW AM	8:00	H2O	x4	8/5											X	X	X	+	X			
2	MSB 2 PW PM	18:45	↓		8/4											X	X	X	X	+			
3	MSB 1 PW PM	19:30			8/4											X	X	X	X	X			
4	MSB 1 PW AM	9:00		x4	8/5											X	X	X	x	y			
5	MSB 1 PW AM MS/MSD	9:00		x2	↓											X	X						
6	MSB 1 PW AM DUP	9:00	↓	x3	↓											X	X	X		X			
7																							
8																							
9																							
10																							

***Metals Analysis (Circle):** MTCA-5 RCRA-8 Priority Pollutants [✓ TAL] *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl U V Zn

****Anions (Circle):** Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

® Si - DISSOLVED

Relinquished x	Date/Time 4P 8/5/2010	Received x	Date/Time 8/9/10 13:44
Relinquished x	Date/Time	Received x	Date/Time

Sample Receipt:	
Good?	Y
Cooler Temperature:	6.3
Seals Intact?:	N/A
Total Number of Containers:	21

Special Remarks:

TAT --> 24HR [✓ 48HR] Standard

Distribution: White - Lab, Yellow - File, Pink - Originator

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Chain of Custody Record

2930 Westlake Ave. N. Suite 100
Seattle, WA 98103

Tel: 206-352-3790
Fax: 206-352-7178

Laboratory Project No (internal): CHM100809-5

Date: 8/6/10

Page: 1 of: 1

Client: EI

Address: 5505 34th Ave. NE

City, State, Zip: Seattle, WA 98105

Tel: 206 525 3362

Project Name: UCR Pore Water

Location:

Collected by: Maria Brumm

Reports To (PM): Whitney Fraser

Fax: 206 525 0869

Email: Whitney.Fraser@eiltd.net

Project No:

Sample Name	Time	Sample Type (Matrix)	Container Type	Date of Collection	VOA 8260	VOA 8021B BTEX	NWTPH-Gx	NWTPH-HCID	NWTPH-Dx/Dx Ext.	SEMI VOL 8270C	PAH 8270	PCBs 8082	Cl PESTICIDES 8081	Cl HERBICIDES 8151A	Metals*	[✓ Total (T)] | [✓ Dissolved (D)]	Anions (IC)** / Alkalinity	TOC				Comments/Depth
1 UDE-PW-02 PM	1820	W		8/5/10											X	X	X	X				
2 UDE-PW-02 AM	0730	W		8/6/10											X	X	X	X				
3 UDE-PW-01 AM	0640	W		8/6/10											X	X	X	X				
4 UDE-1 PW PM	1710	W		8/5/10											X	X	X					
5 UDE-PW 01 PM	1710	W		8/5/10														X				
6 Rinsate Blank 3	0755	W														X						
7 Rinsate Blank 4	0800 Rd ~~0755~~	W														X						
8																						
9																						
10																						

*Metals Analysis (Circle): MTCA-5 RCRA-8 Priority Pollutants [✓ TAL] *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl U V Zn

**Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite (*) Si DISSOLVED

Relinquished x	Date/Time 8/9/10 1300	Received x	Date/Time 8/9/10 13:44
Relinquished x	Date/Time	Received x	Date/Time

Sample Receipt:

Good?	Y
Cooler Temperature:	8.6
Seals Intact?:	N/A
Total Number of Containers:	18

Special Remarks:

3

TAT -> 24HR [✓ 48HR] Standard

Distribution: White - Lab, Yellow - File, Pink - Originator

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Chain of Custody Record

2930 Westlake Ave. N. Suite 100
Seattle, WA 98103

Tel: 206-352-3790
Fax: 206-352-7178

Laboratory Project No (internal): CHM100809-6

Date: 8/5

Page: 1 of: 2

Client: EEI ENVIRONMENT INTERNATIONAL

Project Name: UCR PORE WATER

Address:

Location:

City, State, Zip:

Tel:

Collected by: MARIA BRUNY

Reports To (PM):

Fax:

Email:

Project No:

Sample Name	Time	Sample Type (Matrix)	Container Type	Date of Collection	VOA 8260	VOA 8021B BTEX	NWTPH-Gx	NWTPH-HCID	NWTPH-Dx/Dx Ext.	SEMI VOL 8270C	PAH 8270	PCBs 8082	Cl PESTICIDES 8081	Cl HERBICIDES 8151A	Metals*	Total (T) | Dissolved (D)	Anions (IC)**	TOC	ALKALINITY			Comments/Depth
✓ 1 BSB 1 SED	2PM	SEDIMENT	x2	8/3											X			X				
✓ 2 BSB 2SED	2:10PM	SED	x 2	8/3											X			X				
✓ 3 DE 2 SED	2:50P	SED	x 2	8/4											X			X				
✓ 4 DE 1 SED	3:15P	SED	x2	8/4											X			X				
✓ 5 MSB 1 SED	9:15A	SED	x 2	8/4											X			X				
✓ 6 MSB 2 SED	9:30A	SED	x2	8/4											X			X				
✓ 7 UDE 1 SD MS/MSD	10:50	SED	x1 8oz	8/5											X							
✓ 8 UDE 1 SED DUP	10:55	SED	x1 8oz	8/5											X							
✓ 9 UDE 1 SED	10:45	SED	x2	8/5											X			X				
✓ 10 BSB 2 PW AM	7:15	WATER	x4	8/4											X	T/D	X	X	X			

*Metals Analysis (Circle): MTCA-5 RCRA-8 Priority Pollutants [✓ TAL] *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg ~~Mn~~ Mo Na Ni Pb Sb Se Sr Sn Ti Tl U V Zn

**Anions (Circle): Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite (*) Si - DISSOLVED

Relinquished x	Date/Time 8/5/2010 2:30P	Received x	Date/Time 8/9/10 13:44
Relinquished x	Date/Time	Received x	Date/Time

Sample Receipt:

Good?	Y
Cooler Temperature:	9.6
Seals Intact?:	N/A
Total Number of Containers:	24

Special Remarks:

TAT -> 24HR [✓ 48HR] Standard

Distribution: White - Lab, Yellow - File, Pink - Originator

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Chain of Custody Record

2930 Westlake Ave. N. Suite 100
Seattle, WA 98103

Tel: 206-352-3790
Fax: 206-352-7178

Laboratory Project No (internal):

Date: 8/5

Page: 2 of: 2

Client: ENVIRONMENT INTERNATIONAL

Project Name: UCR PORENATOR

Address:

Location:

City, State, Zip

Tel:

Collected by:

Reports To (PM):

Fax:

Email:

Project No:

	Sample Name	Time	Sample Type (Matrix)	Container Type	Date of Collection	VOA 8260	VOA 8021B BTEX	NWTPH-Gx	NWTPH-HCID	NWTPH-Dx/Dx Ext.	SEMI VOL 8270C	PAH 8270	PCBs 8082	Cl PESTICIDES 8081	Cl HERBICIDES 8151A	Metals*	Total (T) | Dissolved (D)	Anions (IC)**	TOC	ALKALINITY			Comments/Depth
1	BSB 2 PW PM	5:30P	H2O	x4	8/3											X	T/D	X	X	X			
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
10																							

***Metals Analysis (Circle):** MTCA-5 RCRA-8 Priority Pollutants [✓ TAL] *Individual:* Ag Al As B Ba Be Ca Cd Co Cr Cu Fe Hg K Mg Mn Mo Na Ni Pb Sb Se Sr Sn Ti Tl U V Zn

****Anions (Circle):** Nitrate Nitrite Chloride Sulfate Bromide O-Phosphate Fluoride Nitrate+Nitrite

⊛ Si DISSOLVED

Relinquished	Date/Time	Received	Date/Time
x	8/5/2010 2:30P	x	
Relinquished	Date/Time	Received	Date/Time
x		x	

Sample Receipt:

Good?	
Cooler Temperature:	
Seals Intact?:	
Total Number of Containers:	

Special Remarks:

TAT --> 24HR [✓ 48HR] Standard

Distribution: White - Lab, Yellow - File, Pink - Originator

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Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 (ug/L)	MRL	*Original* Method Blank	Method Blank	*Original* LCS	LCS
Date Extracted		8/10/10	9/2/10	8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10	8/10/10	9/3/10
Matrix					
Aluminum (Al)	55	nd	nd	106%	73.1%
Antimony (Sb)	0.20	nd	nd	111%	121%
Arsenic (As)	1.0	nd	nd	88.6%	91.9%
Barium (Ba)	0.30	nd	nd	102%	120%
Beryllium (Be)	0.20	nd	nd	95.2%	96.7%
Cadmium (Cd)	0.20	nd	nd	105%	102%
Calcium (Ca)	100	nd	nd	111%	96.1%
Chromium (Cr)	0.60	nd	nd	105%	99.0%
Cobalt (Co)	0.30	nd	nd	117%	103%
Copper (Cu)	0.40	nd	nd	109%	93.0%
Iron (Fe)	100	nd	nd	114%	89.1%
Lead (Pb)	0.20	nd	nd	117%	96.4%
Magnesium (Mg)	100	nd	nd	107%	71.4%
Manganese (Mn)	1.0	nd	nd	100%	110%
Potassium (K)	500	nd	nd	89%	83.8%
Nickel (Ni)	0.50	nd	nd	110%	105%
Selenium (Se)	1.0	nd	nd	93.3%	108%
Silver (Ag)	0.20	nd	nd	101%	105%
Sodium (Na)	100	nd	nd	111%	82.2%
Thallium (Tl)	0.20	nd	nd	122%	101%
Vanadium (V)	0.50	nd	nd	95.8%	106%
Zinc (Zn)	1.5	nd	nd	81.9%	98.9%

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Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*Re-analysis*
EPA 200.8 (ug/L)	**MRL**	**BSB1 PW PM**	**BSB1 PW PM**
Date Extracted		8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10
Matrix		Water	Water
Aluminum (Al)	55	nd	nd
Antimony (Sb)	0.20	**88.5**	**107**
Arsenic (As)	1.0	nd	nd
Barium (Ba)	0.30	**146**	**181**
Beryllium (Be)	0.20	nd	**0.207**
Cadmium (Cd)	0.20	**0.345**	**0.543**
Calcium (Ca)	100	**37,600**	**37,600**
Chromium (Cr)	0.60	**2.05**	**2.75**
Cobalt (Co)	0.30	nd	**0.341**
Copper (Cu)	0.40	**8.55**	**20.4**
Iron (Fe)	100	nd	nd
Lead (Pb)	0.20	nd	**0.384**
Magnesium (Mg)	100	**5160**	**4510**
Manganese (Mn)	1.0	**8.11**	**18.7**
Potassium (K)	500	**3960**	**1170**
Nickel (Ni)	0.50	nd	**0.828**
Selenium (Se)	1.0	nd	nd
Silver (Ag)	0.20	nd	nd
Sodium (Na)	100	**2930**	**2440**
Thallium (Tl)	0.20	nd	nd
Vanadium (V)	0.50	**0.582**	**1.94**
Zinc (Zn)	1.5	**109**	**125**

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*Re-analysis*
EPA 200.8 (ug/L)	**MRL**	**DE2 PW PM**	**DE2 PW PM**
Date Extracted		8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10
Matrix		Water	Water
Aluminum (Al)	55	nd	nd
Antimony (Sb)	0.20	**369**	**452**
Arsenic (As)	1.0	nd	nd
Barium (Ba)	0.30	**173**	**222**
Beryllium (Be)	0.20	nd	**0.322**
Cadmium (Cd)	0.20	nd	**0.270**
Calcium (Ca)	100	**70,000**	**66,500**
Chromium (Cr)	0.60	**2.05**	**4.65**
Cobalt (Co)	0.30	nd	nd
Copper (Cu)	0.40	**16.7**	**17.6**
Iron (Fe)	100	**303**	nd
Lead (Pb)	0.20	**0.685**	**0.317**
Magnesium (Mg)	100	**8410**	**6670**
Manganese (Mn)	1.0	**2.44**	**1.33**
Potassium (K)	500	**3445**	**1310**
Nickel (Ni)	0.50	nd	**1.57**
Selenium (Se)	1.0	nd	nd
Silver (Ag)	0.20	nd	nd
Sodium (Na)	100	**2410**	**2040**
Thallium (Tl)	0.20	nd	nd
Vanadium (V)	0.50	nd	**2.23**
Zinc (Zn)	1.5	**77.5**	**62.1**

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*Re-analysis*
EPA 200.8 (ug/L)	**MRL**	**DE1 PW AM**	**DE1 PW AM**
Date Extracted		8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10
Matrix		Water	Water
Aluminum (Al)	55	nd	nd
Antimony (Sb)	0.20	**12.1**	**16.0**
Arsenic (As)	1.0	nd	nd
Barium (Ba)	0.30	**115**	**164**
Beryllium (Be)	0.20	nd	nd
Cadmium (Cd)	0.20	nd	**0.346**
Calcium (Ca)	100	**53,100**	**60,000**
Chromium (Cr)	0.60	**2.34**	**5.05**
Cobalt (Co)	0.30	nd	nd
Copper (Cu)	0.40	**3.97**	**3.94**
Iron (Fe)	100	nd	nd
Lead (Pb)	0.20	nd	nd
Magnesium (Mg)	100	**8480**	**7470**
Manganese (Mn)	1.0	nd	nd
Potassium (K)	500	**3960**	**1258**
Nickel (Ni)	0.50	nd	**1.91**
Selenium (Se)	1.0	nd	nd
Silver (Ag)	0.20	nd	nd
Sodium (Na)	100	**2180**	**1920**
Thallium (Tl)	0.20	nd	nd
Vanadium (V)	0.50	**0.694**	**1.74**
Zinc (Zn)	1.5	**58.4**	**46.6**

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*Re-analysis*
EPA 200.8 (ug/L)	**MRL**	**MSB 2 PW AM**	**MSB 2 PW AM**
Date Extracted		8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10
Matrix		Water	Water
Aluminum (Al)	55	**259**	**136**
Antimony (Sb)	0.20	**9.99**	**15.3**
Arsenic (As)	1.0	nd	nd
Barium (Ba)	0.30	**47.1**	**69.2**
Beryllium (Be)	0.20	nd	**0.423**
Cadmium (Cd)	0.20	nd	**0.387**
Calcium (Ca)	100	**33,100**	**35,300**
Chromium (Cr)	0.60	**1.01**	**4.80**
Cobalt (Co)	0.30	nd	**0.620**
Copper (Cu)	0.40	**5.25**	**11.5**
Iron (Fe)	100	**727**	**1210**
Lead (Pb)	0.20	**8.41**	**9.34**
Magnesium (Mg)	100	**6760**	**4960**
Manganese (Mn)	1.0	**20.2**	**29.3**
Potassium (K)	500	**10,100**	**1460**
Nickel (Ni)	0.50	nd	nd
Selenium (Se)	1.0	nd	**3.76**
Silver (Ag)	0.20	nd	nd
Sodium (Na)	100	**2350**	**1690**
Thallium (Tl)	0.20	nd	nd
Vanadium (V)	0.50	**0.794**	**2.99**
Zinc (Zn)	1.5	**153**	**116**

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*Re-analysis*
EPA 200.8 (ug/L)	**MRL**	**MSB 1 PW PM**	**MSB 1 PW PM**
Date Extracted		8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10
Matrix		Water	Water
Aluminum (Al)	55	nd	nd
Antimony (Sb)	0.20	**13.1**	**16.9**
Arsenic (As)	1.0	**2.45**	**4.30**
Barium (Ba)	0.30	**38.5**	**57.8**
Beryllium (Be)	0.20	nd	**0.338**
Cadmium (Cd)	0.20	nd	nd
Calcium (Ca)	100	**28,500**	**29,600**
Chromium (Cr)	0.60	**0.76**	**4.70**
Cobalt (Co)	0.30	nd	nd
Copper (Cu)	0.40	**1.58**	**2.87**
Iron (Fe)	100	**29.0**	nd
Lead (Pb)	0.20	nd	**0.374**
Magnesium (Mg)	100	**6920**	**5270**
Manganese (Mn)	1.0	nd	nd
Potassium (K)	500	**7490**	**567**
Nickel (Ni)	0.50	nd	nd
Selenium (Se)	1.0	nd	nd
Silver (Ag)	0.20	nd	nd
Sodium (Na)	100	**2100**	**1670**
Thallium (Tl)	0.20	nd	nd
Vanadium (V)	0.50	nd	**3.67**
Zinc (Zn)	1.5	**32.3**	**28.1**

Analysis of Total Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*Re-analysis*
EPA 200.8 (ug/L)	**MRL**	**BSB 2 PW AM**	**BSB 2 PW AM**
Date Extracted		8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10
Matrix		Water	Water
Aluminum (Al)	55	nd	**193**
Antimony (Sb)	0.20	**15.7**	**19.3**
Arsenic (As)	1.0	nd	nd
Barium (Ba)	0.30	**73.4**	**99.8**
Beryllium (Be)	0.20	nd	**0.324**
Cadmium (Cd)	0.20	nd	**0.549**
Calcium (Ca)	100	**19,600**	**23,100**
Chromium (Cr)	0.60	**3.05**	**4.85**
Cobalt (Co)	0.30	nd	**0.596**
Copper (Cu)	0.40	**22.2**	**15.4**
Iron (Fe)	100	**130**	**2050**
Lead (Pb)	0.20	**5.72**	**3.97**
Magnesium (Mg)	100	**4270**	**3730**
Manganese (Mn)	1.0	nd	**43.3**
Potassium (K)	500	**10,500**	**1540**
Nickel (Ni)	0.50	nd	**1.59**
Selenium (Se)	1.0	nd	nd
Silver (Ag)	0.20	nd	nd
Sodium (Na)	100	**1780**	**1630**
Thallium (Tl)	0.20	nd	nd
Vanadium (V)	0.50	nd	nd
Zinc (Zn)	1.5	**29.8**	**105**

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MRL**	*Original* **Method Blank**	**Method Blank**	*Original* **LCS**	**LCS**
Date Extracted		8/10/10	9/2/10	8/10/10	9/2/10
Date Analyzed		8/10/10	9/3/10	8/10/10	9/3/10
Matrix					
Aluminum (Al)	55	nd	nd	90.8%	85.3%
Antimony (Sb)	0.20	nd	nd	90.3%	104%
Arsenic (As)	1.0	nd	nd	96.4%	90.2%
Barium (Ba)	0.30	nd	nd	89.0%	109%
Beryllium (Be)	0.20	nd	nd	112.0%	121%
Cadmium (Cd)	0.20	nd	nd	98.0%	105%
Calcium (Ca)	100	nd	nd	95.3%	93.3%
Chromium (Cr)	0.60	**0.970**	nd	94.5%	98.7%
Cobalt (Co)	0.30	nd	nd	110.0%	102%
Copper (Cu)	0.40	nd	nd	110.0%	108%
Iron (Fe)	100	nd	nd	98.8%	89.9%
Lead (Pb)	0.20	nd	nd	101.0%	102%
Magnesium (Mg)	100	nd	nd	90.4%	83.6%
Manganese (Mn)	1.0	nd	nd	93.5%	108%
Nickel (Ni)	0.50	nd	nd	106.0%	104%
Potassium (K)	500	nd	nd	113.6%	104%
Selenium (Se)	1.0	nd	nd	102.0%	127%
Silver (Ag)	0.20	nd	nd	88.7%	96.5%
Sodium (Na)	100	nd	nd	103.4%	125%
Thallium (Tl)	0.20	nd	nd	106.0%	105%
Vanadium (V)	0.50	nd	nd	90.2%	98.1%
Zinc (Zn)	1.5	nd	nd	99.3%	88.6%

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MRL**	*Original* **BSB1 PW PM**	*EI Sample Re-analysis* **BSB1 PW PM**	*FAI Filter Analyze* **BSB1 PW PM**
Date Extracted		8/10/10	9/2/10	9/2/10
Date Analyzed		8/10/10	9/3/10	9/3/10
Matrix		Water	Water	Water
Aluminum (Al)	55	nd	nd	nd
Antimony (Sb)	0.20	**76.7**	**83.9**	**85.0**
Arsenic (As)	1.0	nd	nd	**1.01**
Barium (Ba)	0.30	**127**	**150**	**142**
Beryllium (Be)	0.20	**1.32**	nd	nd
Cadmium (Cd)	0.20	**0.438**	**0.635**	**0.413**
Calcium (Ca)	100	**35,200**	**34,000**	**33,200**
Chromium (Cr)	0.60	**2.41**	**1.22**	**3.87**
Cobalt (Co)	0.30	nd	nd	nd
Copper (Cu)	0.40	**8.98**	**4.44**	**14.5**
Iron (Fe)	100	nd	nd	nd
Lead (Pb)	0.20	**2.81**	nd	nd
Magnesium (Mg)	100	**4880**	**4900**	**4070**
Manganese (Mn)	1.0	**11.8**	**14.7**	**11.0**
Nickel (Ni)	0.50	nd	nd	nd
Potassium (K)	500	**5980**	**2240**	**1800**
Selenium (Se)	1.0	nd	nd	nd
Silver (Ag)	0.20	nd	nd	nd
Sodium (Na)	100	**2490**	**5180**	**2780**
Thallium (Tl)	0.20	nd	nd	nd
Vanadium (V)	0.50	**1.54**	nd	nd
Zinc (Zn)	1.5	**153**	**126**	**118**

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*EI Sample Re-analysis*	*FAI Filter Analyze*
EPA 200.8 (ug/L)	**MRL**	**DE2 PW PM**	**DE2 PW PM**	**DE2 PW PM**
Date Extracted		8/10/10	9/2/10	9/2/10
Date Analyzed		8/10/10	9/3/10	9/3/10
Matrix		Water	Water	Water
Aluminum (Al)	55	nd	**128**	nd
Antimony (Sb)	0.20	**344**	**383**	**361**
Arsenic (As)	1.0	**1.97**	nd	nd
Barium (Ba)	0.30	**149**	**193**	**173**
Beryllium (Be)	0.20	**1.62**	nd	**0.296**
Cadmium (Cd)	0.20	**0.251**	**0.264**	**0.409**
Calcium (Ca)	100	**69,400**	**65,400**	**62,700**
Chromium (Cr)	0.60	**3.56**	**4.61**	**6.18**
Cobalt (Co)	0.30	nd	nd	**0.374**
Copper (Cu)	0.40	**14.4**	**14.5**	**19.6**
Iron (Fe)	100	nd	**220**	nd
Lead (Pb)	0.20	**2.59**	nd	**0.225**
Magnesium (Mg)	100	**9800**	**8010**	**8540**
Manganese (Mn)	1.0	nd	**7.64**	nd
Nickel (Ni)	0.50	nd	nd	nd
Potassium (K)	500	**7290**	**2980**	**2990**
Selenium (Se)	1.0	nd	nd	nd
Silver (Ag)	0.20	nd	nd	nd
Sodium (Na)	100	**3920**	**3161**	**2450**
Thallium (Tl)	0.20	nd	nd	nd
Vanadium (V)	0.50	**1.48**	**0.797**	nd
Zinc (Zn)	1.5	**100**	**74.2**	**68.9**

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MRL**	*Original* **DE1 PW AM**	*EI Sample Re-analysis* **DE1 PW AM**	*FAI Filter Analyze* **DE1 PW AM**
Date Extracted		8/10/10	9/2/10	9/2/10
Date Analyzed		8/10/10	9/3/10	9/3/10
Matrix		Water	Water	Water
Aluminum (Al)	55	**694**	**1058**	**106**
Antimony (Sb)	0.20	**11.7**	**14.61**	**11.1**
Arsenic (As)	1.0	**1.08**	nd	nd
Barium (Ba)	0.30	**135**	**182**	**121**
Beryllium (Be)	0.20	**1.28**	nd	nd
Cadmium (Cd)	0.20	**0.643**	**0.395**	**0.266**
Calcium (Ca)	100	**54,100**	**52,400**	**45,800**
Chromium (Cr)	0.60	**6.74**	**9.17**	**6.03**
Cobalt (Co)	0.30	**1.15**	**0.857**	**0.659**
Copper (Cu)	0.40	**47.4**	**55.2**	**12.8**
Iron (Fe)	100	**6730**	**6630**	nd
Lead (Pb)	0.20	**32.0**	**19.5**	nd
Magnesium (Mg)	100	**10,200**	**10400**	**6940**
Manganese (Mn)	1.0	**153**	**175**	**1.09**
Nickel (Ni)	0.50	**0.612**	**1.40**	nd
Potassium (K)	500	**7880**	**2227**	**1690**
Selenium (Se)	1.0	**3.58**	nd	nd
Silver (Ag)	0.20	nd	nd	nd
Sodium (Na)	100	**2000**	**4640**	**2120**
Thallium (Tl)	0.20	nd	nd	nd
Vanadium (V)	0.50	nd	nd	nd
Zinc (Zn)	1.5	**630**	**480**	**46.0**

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Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MRL**	*Original* **MSB 2 PW AM**	*EI Sample Re-analysis* **MSB 2 PW AM**	*FAI Filter Analyze* **MSB 2 PW AM**
Date Extracted		8/10/10	9/2/10	9/2/10
Date Analyzed		8/10/10	9/3/10	9/3/10
Matrix		Water	Water	Water
Aluminum (Al)	55	nd	nd	nd
Antimony (Sb)	0.20	**9.56**	**11.9**	**11.8**
Arsenic (As)	1.0	nd	nd	nd
Barium (Ba)	0.30	**39.1**	**55.3**	**54.1**
Beryllium (Be)	0.20	**1.27**	nd	nd
Cadmium (Cd)	0.20	nd	nd	nd
Calcium (Ca)	100	**29,300**	**30,700**	**29,500**
Chromium (Cr)	0.60	**2.62**	**4.92**	**5.40**
Cobalt (Co)	0.30	nd	nd	nd
Copper (Cu)	0.40	**10.5**	**2.72**	**8.27**
Iron (Fe)	100	nd	nd	nd
Lead (Pb)	0.20	**3.90**	nd	nd
Magnesium (Mg)	100	**4950**	**4670**	**4850**
Manganese (Mn)	1.0	nd	**1.30**	**4.02**
Nickel (Ni)	0.50	**0.588**	nd	nd
Potassium (K)	500	**5390**	**2470**	**2120**
Selenium (Se)	1.0	nd	nd	nd
Silver (Ag)	0.20	nd	nd	nd
Sodium (Na)	100	**1550**	**2160**	**2330**
Thallium (Tl)	0.20	nd	nd	nd
Vanadium (V)	0.50	**0.840**	**0.707**	nd
Zinc (Zn)	1.5	**79.6**	**82.4**	**73.8**

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

		Original	*EI Sample Re-analysis*	*FAI Filter Analyze*
EPA 200.8 (ug/L)	**MRL**	**MSB 1 PW PM**	**MSB 1 PW PM**	**MSB 1 PW PM**
Date Extracted		8/10/10	9/2/10	9/2/10
Date Analyzed		8/10/10	9/3/10	9/3/10
Matrix		Water	Water	Water
Aluminum (Al)	55	nd	**301**	**131**
Antimony (Sb)	0.20	**11.1**	**13.8**	**14.6**
Arsenic (As)	1.0	**2.51**	nd	nd
Barium (Ba)	0.30	**33.8**	**61.6**	**71.2**
Beryllium (Be)	0.20	**1.31**	nd	nd
Cadmium (Cd)	0.20	nd	nd	nd
Calcium (Ca)	100	**27,500**	**27,200**	**17,200**
Chromium (Cr)	0.60	**2.58**	**4.89**	**4.57**
Cobalt (Co)	0.30	nd	**0.500**	**0.617**
Copper (Cu)	0.40	**5.78**	**4.24**	**12.1**
Iron (Fe)	100	nd	**381**	nd
Lead (Pb)	0.20	**3.01**	**0.596**	nd
Magnesium (Mg)	100	**7000**	**6510**	**3930**
Manganese (Mn)	1.0	nd	**13.2**	**5.64**
Nickel (Ni)	0.50	nd	nd	nd
Potassium (K)	500	**2580**	**1550**	**879**
Selenium (Se)	1.0	nd	nd	nd
Silver (Ag)	0.20	nd	nd	nd
Sodium (Na)	100	**2150**	**5850**	**2150**
Thallium (Tl)	0.20	nd	nd	nd
Vanadium (V)	0.50	**0.948**	**1.45**	nd
Zinc (Zn)	1.5	**27.6**	**39.9**	**37.8**

Analysis of Dissolved Metals in Water by EPA Method 200.8

Project: UCR Pore Water
Client: Environment International, LTD.
Client Project #: N/A
Lab Project #: CHM100809-3

EPA 200.8 **(ug/L)**	**MRL**	*Original* **BSB 2 PW AM**	*EI Sample Re-analysis* **BSB 2 PW AM**	*FAI Filter Analyze* **BSB 2 PW AM**
Date Extracted		8/10/10	9/2/10	9/2/10
Date Analyzed		8/10/10	9/3/10	9/3/10
Matrix		Water	Water	Water
Aluminum (Al)	55	nd	nd	**74.8**
Antimony (Sb)	0.20	**13.6**	**14.9**	**10.5**
Arsenic (As)	1.0	nd	nd	**2.53**
Barium (Ba)	0.30	**58.2**	**71.7**	**41.1**
Beryllium (Be)	0.20	**0.390**	nd	nd
Cadmium (Cd)	0.20	nd	nd	nd
Calcium (Ca)	100	**18,800**	**18,500**	**24,200**
Chromium (Cr)	0.60	**1.95**	**3.77**	**4.00**
Cobalt (Co)	0.30	nd	nd	nd
Copper (Cu)	0.40	**4.14**	**1.92**	**18.3**
Iron (Fe)	100	**141**	nd	**130**
Lead (Pb)	0.20	**2.93**	nd	nd
Magnesium (Mg)	100	**4430**	**3790**	**5850**
Manganese (Mn)	1.0	**2.10**	**1.78**	**3.49**
Nickel (Ni)	0.50	nd	nd	nd
Potassium (K)	500	**1410**	**1550**	**1780**
Selenium (Se)	1.0	nd	nd	nd
Silver (Ag)	0.20	nd	nd	nd
Sodium (Na)	100	**1810**	**1460**	**2230**
Thallium (Tl)	0.20	nd	nd	nd
Vanadium (V)	0.50	nd	nd	nd
Zinc (Zn)	1.5	**46.3**	**29.1**	**38.0**

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DATA VALIDATION REVIEW REPORT – EPA LEVEL 2

Project:	Upper Columbia River
Project Number:	100186-01
Date:	September 15, 2010

This report summarizes the review of analytical results for 8 sediment, 17 porewater, and 4 rinse blank samples collected on August 3-6, 2010. Samples were collected by Environment International, and submitted to Fremont Analytical (Fremont) in Seattle, Washington. Samples were analyzed for the following parameters:

- Total and dissolved metals by United States Environmental Protection Agency (USEPA) methods 6020 and 200.8, 7471A, and 7470
- Total organic carbon (TOC) by USEPA methods 9060A and 5310B
- Anions (bromide chloride, fluoride, nitrate, nitrite, ortho-phosphate, and sulfate) by USEPA method 300.0
- Alkalinity by Standard Method 2320B

Fremont sample data group (SDG) number CHM100809-3 was reviewed in this report. The samples reviewed are presented in Table 1.

Table 1
Samples Reviewed

Sample ID	Matrix	Analyses Requested
BSB 1 SED	Sediment	Metals, TOC
BSB 2 SED	Sediment	Metals, TOC
DE 2 SED	Sediment	Metals, TOC
DE 1 SED	Sediment	Metals, TOC
MSB 1 SED	Sediment	Metals, TOC
MSB 2 SED	Sediment	Metals, TOC
UDE 1 SED	Sediment	Metals, TOC
UDE 2 SED	Sediment	Metals, TOC
BSB 2 PW AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
BSB 2 PW PM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
BSB 1 PW AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
BSB 1 PW PM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
DE 1 PW PM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity

Sample ID	Matrix	Analyses Requested
DE 1 PW AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
DE 2 PW PM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
DE 2 PW AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
MSB 2 PW AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
MSB 2 PW PM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
MSB 1 PW PM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
MSB 1 PW AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
UDE-PW-02 PM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
UDE-PW-02 AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
UDE-PW-01 AM	Porewater	Metals (total & dissolved), TOC, Anions, Alkalinity
UDE-PW-01 PM	Porewater	Metals (total & dissolved), Anions, Alkalinity
UDE-1-PW PM	Porewater	TOC
Rinse Blank 1	QC sample	Metals (total & dissolved)
Rinse Blank 2	QC sample	Metals (total & dissolved)
Rinse Blank 3	QC sample	Metals (total & dissolved)
Rinse Blank 4	QC sample	Metals (total & dissolved)

Data Validation and Qualifications

The following comments refer to the laboratory's performance in meeting the quality assurance/quality control (QA/QC) guidelines outlined in the analytical procedures and data quality objective sections of the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP). Laboratory results were reviewed following *USEPA Contract Laboratory Program National Functional Guidelines for Inorganics Data Review* (USEPA 2004) as a guideline, and applying laboratory and method QC criteria as stated in SW 846, Third Edition, *Test Methods for Evaluating Solid Waste*, update 1, July 1992; update IIA, August 1993; update II, September 1994; update IIB, January 1995; update III, December 1996; update IIIA, April 1998. Unless noted in this report, laboratory results for the samples listed above were within QC criteria.

Field Documentation

Field documentation was checked for completeness and accuracy. The chain-of-custody (COC) forms were signed by Fremont at the time of sample receipt; the samples were received cold and in good condition. The cooler temperatures were 9.2°C, 6.3°C, 8.6°C, and 9.6°C which is outside of the recommended <6°C; however, this discrepancy is not expected to impact the results. Based on visual observations (i.e. sediment in the bottom of the container) and analytical results it was determined that sample DE1-PW-AM had total and dissolved fractions mixed up in the field. Laboratory reports match the bottle labels and are thus labeled incorrectly incorrectly.

Holding Times and Sample Preservation and Analytical Methods

Samples were appropriately preserved and analyzed within holding times except for nitrate, nitrite, and ortho-phosphate which were analyzed past the 48-hour hold time. Analyses that were performed past 2 times the holding time and resulted in undetected levels were rejected. All other data were qualified with a "J" to indicate that they are estimated. See Table 3 for qualified data.

Laboratory Method Blanks

Laboratory method blanks were analyzed at the required frequencies. All method blanks were free of target analytes except for metals. Dissolved chromium was detected in the method blank above the method reporting limit (MRL). One associated sample result was significantly greater than (>5x) the method blank and, thus, was not qualified. All other detected sample results were qualified as non-detect. See Table 3 for qualified data.

Field Quality Control

Rinse Blanks

Four rinse blanks were collected with this sample set. Several target analytes were detected above the MRL in the rinse blanks. Detected results are summarized in Table 2. Metals are identified by their atomic symbol.

Table 2
Rinse Blank Detections Summary (µg/L)

Analyte	Rinse Blank 1	Rinse Blank 2	Rinse Blank3	Rinse Blank 4
Al	--	--	--	--
Sb	--	--	--	--
As	--	--	--	--
Ba	5.2	6.49	5.61	5.29
Be	--	--	--	--
Ca	2400	2260	--	--
Cr	1.27	1.7	1.71	1.45
Co	0.411	--	--	--
Cu	4.43	4.15	8.16	3.5
Fe	--	--	--	--

Analyte	Rinse Blank 1	Rinse Blank 2	Rinse Blank3	Rinse Blank 4
Pb	--	--	--	--
Mg	--	--	--	--
Mn	--	--	--	--
Hg	--	--	--	--
Ni	--	--	--	--
Se	3.4	1.04	--	--
Ag	--	--	--	--
K	4100	2970	10800	10200
Na	1240	1240	310	1520
Tl	--	--	--	--
V	--	0.642	0.460	--
Zn	8.71	7.54	0.965	--

-- Indicates result was below detection.

No data were qualified based on rinse blank results.

Field Duplicates

Field duplicates were not collected in association with this sample set.

Matrix Spike (MS) and Matrix Spike Duplicate (MSD)

MS and MSD samples were analyzed at the required frequencies. All MS/MSD analyses yielded percent recoveries (%R) and/or RPD values within the project data quality objectives with the following exceptions:

- Metals (soil): MS and MSD recoveries and/or MS/MSD RPD values for sixteen analytes were outside of control limits. Sample concentrations for six analytes were significantly greater than (>4x) the spike levels, so none of these data were qualified. Antimony recovered below control limits in the MS and MSD. Potassium recovered below limits in the MSD and the MS/MSD RPD value was above control limits. Arsenic, chromium, cobalt, nickel, silver, sodium and thallium recovered high in the MS and/or MSD. Cadmium recovered above limits in the MS and MSD and the MS/MSD RPD value was above control limits. Associated results have been qualified "J" to indicate they are estimated.
- Metals (total water): MS recovery values for four analytes were outside of control limits. Cobalt, iron, lead, and thallium recovered high in the MS. Associated detected results have been qualified "J" to indicate they are estimated.

- Metals (dissolved water): MS and MSD recoveries and/or MS/MSD RPD values for four analytes were outside of control limits. Sodium recovered above control limits in the MS. Calcium, magnesium, and potassium recovered above limits in the MS and/or MSD and the MS/MSD RPD value was above control limits. Associated detected results have been qualified "J" to indicate they are estimated. See Table 3 for qualified data.
- Anions: ortho-phospate recovered above control limits in the MS and MSD. All associated results were either non-detect or rejected, so no data were qualified.

Laboratory Control Sample (LCS)

LCSs were analyzed at the required frequencies and resulted in recoveries within project-required control limits except for metals. Arsenic, potassium, and zinc recovered below control limits. Associated results have been qualified "J" to indicate a potentially low bias. See Table 3 for qualified data.

Laboratory Duplicates

Laboratory duplicates were analyzed at the required frequencies. All RPD values were within project-required control limits with the following exceptions:

- Metals (soil): The duplicate analyses of antimony and cadmium resulted in RPD values above control limits. Associated results have been qualified "J" to indicate that they are estimated.
- Metals (total water): The duplicate analyses of copper and zinc resulted in RPD values above control limits. Associated results have been qualified "J" or "UJ" to indicate that they are estimated. The duplicate analysis of arsenic and cobalt resulted in a RPD value above control limits; however, results were less than 5x the MRL and the difference between them was less than the MRL so no data were qualified.

See Table 3 for qualified data.

Method Reporting Limits

Reporting limits were deemed acceptable as reported. All values were reported using the laboratory reporting limits. Values were reported as undiluted, or when reported as diluted, the reporting limit accurately reflects the dilution factor.

Total and Dissolved Fractions

Several samples yielded significantly higher results for dissolved metals than total metals. The laboratory re-digested (total) and reanalyzed (total and dissolved) six of these samples (BSB1 PW PM, DE2 PW PM, DE1 PW AM, MSB 2 PW AM, MSB 1 PW PM), BSB 2 PW AM) to verify the results of the first analysis. The results of the reanalyses were generally higher for totals and lower for dissolved fractions indicating that the reanalysis may be more accurate. All LCS's in the reanalyzed analytical batches were within project control limits, however; lab duplicates and MS/MSD samples were not reported or assessed to determine if matrix biases were present.

Overall Assessment

As was determined by this evaluation, the laboratory followed the specified analytical methods and all requested sample analyses were completed. Accuracy was generally acceptable as demonstrated by the LCS, and MS/MSD %R values, with the exceptions noted above. Precision was also generally acceptable as demonstrated by the laboratory duplicates and MS/MSD RPD values, with the exceptions noted above. Because matrix interferences were present and total and dissolved metals results were suspect, the laboratory reanalyzed a subset of samples. Some anion data were rejected due to missed holding time. Most data were deemed acceptable as reported; all other data are acceptable as qualified with the exception of some anion data. Table 3 summarizes the qualifiers applied to samples reviewed in this report.

Data Qualifier Definitions

U	Indicates the compound or analyte was analyzed for but not detected at or above the specified limit.
J	Indicates an estimated value.
R	Indicates data is rejected and unusable
UJ	Indicates the compound or analyte was analyzed for but not detected and the specified limit reported is estimated

Table 3
Data Qualification Summary

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
UDE 2 SED	Metals	Antimony	3.83 mg/kg	3.83J mg/kg	High duplicate RPD; low MS/MSD %R
		Arsenic	7.60 mg/kg	7.60J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	3.90 mg/kg	3.90J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	2210 mg/kg	2210 J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD
		Chromium	34.5 mg/kg	34.5 J mg/kg	High MS and/or MSD %R
		Cobalt	11.2 mg/kg	11.2J mg/kg	
		Nickel	8.32 mg/kg	8.32J mg/kg	
		Silver	1.16 mg/kg	1.16J mg/kg	
		Sodium	643 mg/kg	643J mg/kg	
		Thallium	1.68 mg/kg	1.68J mg/kg	
		Zinc	7300 mg/kg	7300J mg/kg	Low LCS %R
BSB 1 SED	Metals	Antimony	18.8 mg/kg	18.8J mg/kg	High duplicate RPD; low MS/MSD %R
		Arsenic	75.3 mg/kg	75.3J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	4.56 mg/kg	4.56J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	5640 mg/kg	5640J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD
		Chromium	148 mg/kg	148J mg/kg	High MS and/or MSD %R
		Cobalt	100 mg/kg	100J mg/kg	
		Nickel	64.7 mg/kg	64.7J mg/kg	
		Silver	8.06 mg/kg	8.06J mg/kg	
		Sodium	3050 mg/kg	3050J mg/kg	
		Thallium	3.01 mg/kg	3.01J mg/kg	
		Zinc	16900 mg/kg	16900J mg/kg	Low LCS %R
BSB 2 SED	Metals	Antimony	15.1 mg/kg	15.1J mg/kg	High duplicate RPD; low MS/MSD %R
		Arsenic	69.9 mg/kg	69.9J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	4.13 mg/kg	4.13J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	6270 mg/kg	6270J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
		Chromium	168 mg/kg	168J mg/kg	High MS and/or MSD %R
		Cobalt	106 mg/kg	106J mg/kg	
		Nickel	59.4 mg/kg	59.4J mg/kg	
		Silver	8.03 mg/kg	8.03J mg/kg	
		Sodium	3250 mg/kg	3250J mg/kg	
		Thallium	2.69 mg/kg	2.69J mg/kg	
		Zinc	18600 mg/kg	18600J mg/kg	Low LCS %R
DE 2 SED	Metals	Antimony	14.3 mg/kg	14.3J mg/kg	High duplicate RPD; low MS/MSD %R
		Arsenic	21.9 mg/kg	21.9J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	1.13 mg/kg	1.13J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	4840 mg/kg	4840J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD
		Chromium	80.0 mg/kg	80.0J mg/kg	High MS and/or MSD %R
		Cobalt	44.4 mg/kg	44.4J mg/kg	
		Nickel	10.8 mg/kg	10.8J mg/kg	
		Silver	4.00 mg/kg	4.00J mg/kg	
		Sodium	1040 mg/kg	1040J mg/kg	
		Thallium	0.910 mg/kg	0.910J mg/kg	
		Zinc	8460 mg/kg	8460J mg/kg	Low LCS %R
DE 1 SED	Metals	Antimony	3.32 mg/kg	3.32J mg/kg	High duplicate RPD; low MS/MSD %R
		Arsenic	8.32 mg/kg	8.32J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	1.86 mg/kg	1.86J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	5140 mg/kg	5140J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD
		Chromium	48.4 mg/kg	48.4J mg/kg	High MS and/or MSD %R
		Cobalt	17.9 mg/kg	17.9J mg/kg	
		Nickel	6.16 mg/kg	6.16J mg/kg	
		Silver	2.11 mg/kg	2.11J mg/kg	
		Sodium	963 mg/kg	963J mg/kg	
		Thallium	1.68 mg/kg	1.68J mg/kg	
		Zinc	9400 mg/kg	9400J mg/kg	Low LCS %R
MSB 1 SED	Metals	Antimony	2.84 mg/kg	2.84J mg/kg	High duplicate RPD; low MS/MSD %R

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
		Arsenic	7.66 mg/kg	7.66J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	1.59 mg/kg	1.59J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	2900 mg/kg	2900J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD
		Chromium	22.0 mg/kg	22.0J mg/kg	High MS and/or MSD %R
		Cobalt	8.64 mg/kg	8.64J mg/kg	
		Nickel	5.05 mg/kg	5.05J mg/kg	
		Silver	0.890 mg/kg	0.890J mg/kg	
		Sodium	391 mg/kg	391J mg/kg	
		Thallium	0.960 mg/kg	0.960J mg/kg	
		Zinc	4670 mg/kg	4670J mg/kg	Low LCS %R
MSB 2 SED	Metals	Antimony	6.59 mg/kg	6.59J mg/kg	High duplicate RPD; low MS/MSD %R
		Arsenic	9.33 mg/kg	9.33J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	1.95 mg/kg	1.95J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	1910 mg/kg	1910J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD
		Chromium	34.2 mg/kg	34.2J mg/kg	High MS and/or MSD %R
		Cobalt	10.0 mg/kg	10.0J mg/kg	
		Nickel	2.70 mg/kg	2.70J mg/kg	
		Silver	0.630 mg/kg	0.630J mg/kg	
		Sodium	472 mg/kg	472J mg/kg	
		Thallium	1.38 mg/kg	1.38J mg/kg	
		Zinc	5450 mg/kg	5450J mg/kg	Low LCS %R
UDE 1 SED	Metals	Antimony	7.30 mg/kg	7.30J mg/kg	High duplicate RPD; low MS/MSD %R
		Arsenic	13.2 mg/kg	13.2J mg/kg	Low LCS %R; High MS/MSD %R
		Cadmium	1.68 mg/kg	1.68J mg/kg	High duplicate RPD; High MS/MSD %R; High MS/MSD RPD
		Potassium	5490 mg/kg	5490J mg/kg	Low LCS %R; Low MS/MSD %R; High MS/MSD RPD
		Chromium	66.2 mg/kg	66.2J mg/kg	High MS and/or MSD
		Cobalt	30.9 mg/kg	30.9J mg/kg	

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
		Nickel	8.08 mg/kg	8.08J mg/kg	%R
		Silver	2.59 mg/kg	2.59J mg/kg	
		Sodium	1450 mg/kg	1450J mg/kg	
		Thallium	1.41 mg/kg	1.41J mg/kg	
		Zinc	12600 mg/kg	12600J mg/kg	Low LCS %R
BSB1 PW AM	Total Metals	Copper	50.5 µg/L	50.5J µg/L	High duplicate RPD
		Zinc	263 µg/L	263J µg/L	
		Cobalt	0.189 µg/L	0.189J µg/L	High MS %R
		Iron	2100 µg/L	2100J µg/L	
		Lead	30.3 µg/L	30.3J µg/L	
		Thallium	0.221 µg/L	0.221J µg/L	
	Anions	Nitrate	0.208 mg/L	0.208J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	
BSB1 PW PM	Total Metals	Copper	8.55 µg/L	8.55J µg/L	High duplicate RPD
		Zinc	109 µg/L	109J µg/L	
	Anions	Nitrate	0.294 mg/L	0.294J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	
DE2 PW PM	Total Metals	Copper	16.7 µg/L	16.7J µg/L	High duplicate RPD
		Zinc	77.5 µg/L	77.5J µg/L	
		Iron	303 µg/L	303J µg/L	High MS %R
		Lead	0.685 µg/L	0.685J µg/L	
	Anions	Nitrate	2.47 mg/L	2.47J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	
DE1 PW AM	Total Metals	Copper	3.97 µg/L	3.97J µg/L	High duplicate RPD
		Zinc	58.4 µg/L	58.4J µg/L	
	Anions	Nitrate	2.03 mg/L	2.03J mg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1UJ mg/L	
		Ortho-phosphate	0.1U mg/L	0.1UJ mg/L	
Rinsate Blank 1	Total Metals	Copper	4.43 µg/L	4.43J µg/L	High duplicate RPD
		Zinc	8.71 µg/L	8.71J µg/L	
		Cobalt	0.411 µg/L	0.411J µg/L	High MS %R
Rinsate Blank 2	Total Metals	Copper	4.15 µg/L	4.15J µg/L	High duplicate RPD
		Zinc	7.54 µg/L	7.54J µg/L	
DE1 PW PM	Total Metals	Copper	4.27 µg/L	4.27J µg/L	High duplicate RPD
		Zinc	79.7 µg/L	79.7J µg/L	
		Iron	128 µg/L	128J µg/L	High MS %R
	Anions	Nitrate	1.27 mg/L	1.27J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
DE2 PW AM	Total Metals	Copper	19.7 µg/L	19.7J µg/L	High duplicate RPD
		Zinc	63.8 µg/L	63.8J µg/L	
		Iron	100 µg/L	100J µg/L	High MS %R
	Anions	Nitrate	1.73 mg/L	1.73J mg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1UJ mg/L	
		Ortho-phosphate	0.1U mg/L	0.1UJ mg/L	
MSB 2 PW AM	Total Metals	Copper	5.25 µg/L	5.25J µg/L	High duplicate RPD
		Zinc	153 µg/L	153J µg/L	
		Iron	727 µg/L	727J µg/L	High MS %R
		Lead	8.41 µg/L	8.41J µg/L	
	Anions	Nitrate	1.19 mg/L	1.19J mg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1UJ mg/L	
		Ortho-phosphate	0.1U mg/L	0.1UJ mg/L	
MSB 2 PW PM	Total Metals	Copper	5.32 µg/L	5.32J µg/L	High duplicate RPD
		Zinc	77.7 µg/L	77.7J µg/L	
		Lead	0.915 µg/L	0.915J µg/L	High MS %R
	Anions	Nitrate	0.551 mg/L	0.551J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	
MSB 1 PW PM	Total Metals	Copper	1.58 µg/L	1.58J µg/L	High duplicate RPD
		Zinc	32.3 µg/L	32.3J µg/L	
		Iron	29.0 µg/L	29.0J µg/L	High MS %R
	Anions	Nitrate	0.348 mg/L	0.348J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	
MSB 1 PW AM	Total Metals	Copper	4.01 µg/L	4.01J µg/L	High duplicate RPD
		Zinc	70.7 µg/L	70.7J µg/L	
		Cobalt	0.420 µg/L	0.420J µg/L	High MS %R
		Iron	370 µg/L	370J µg/L	
		Lead	4.95 µg/L	4.95J µg/L	
	Anions	Nitrate	0.318 mg/L	0.318Jmg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1UJ mg/L	
		Ortho-phosphate	0.1U mg/L	0.1UJ mg/L	
UDE-PW-02-PM	Total Metals	Copper	13.7 µg/L	13.7J µg/L	High duplicate RPD
		Zinc	118 µg/L	118J µg/L	
		Iron	1060 µg/L	1060J µg/L	High MS %R
		Lead	11.0 µg/L	11.0J µg/L	
	Anions	Nitrate	0.1U mg/L	0.1UJ mg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1UJ mg/L	
		Ortho-phosphate	0.1U mg/L	0.1UJ mg/L	
UDE-PW-02-AM	Total Metals	Copper	7.53 µg/L	7.53J µg/L	High duplicate RPD

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
		Zinc	40.5 µg/L	40.5J µg/L	
		Iron	41.3 µg/L	41.3J µg/L	High MS %R
	Anions	Nitrate	0.176 mg/L	0.176J mg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1UJ mg/L	
		Ortho-phosphate	0.1U mg/L	0.1UJ mg/L	
UDE-PW-01-AM	Total Metals	Copper	12.8 µg/L	12.8J µg/L	High duplicate RPD
		Zinc	63.2 µg/L	63.2J µg/L	
		Iron	447 µg/L	447J µg/L	High MS %R
		Lead	2.95 µg/L	2.95J µg/L	
	Anions	Nitrate	0.222 mg/L	0.222J mg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1UJ mg/L	
		Ortho-phosphate	0.1U mg/L	0.1UJ mg/L	
UDE-1 PW PM	Total Metals	Copper	4.5 µg/L	4.5J µg/L	High duplicate RPD
		Zinc	17.5 µg/L	17.5J µg/L	
		Iron	284 µg/L	284J µg/L	High MS %R
	Anions	Nitrate	0.212 mg/L	0.212J mg/L	Missed holding time
		Nitrite	0.1U mg/L	0.1U mg/L	
		Ortho-phosphate	0.1U mg/L	0.1U mg/L	
Rinsate Blank 3	Total Metals	Copper	8.16 µg/L	8.16J µg/L	High duplicate RPD
		Zinc	0.965 µg/L	0.965J µg/L	
Rinsate Blank 4	Total Metals	Copper	3.50 µg/L	3.50J µg/L	High duplicate RPD
		Zinc	1.5U µg/L	1.5UJ µg/L	
BSB 2 PW AM	Total Metals	Copper	22.2 µg/L	22.2J µg/L	High duplicate RPD
		Zinc	29.8 µg/L	29.8J µg/L	
		Iron	130 µg/L	130J µg/L	High MS %R
		Lead	5.72 µg/L	5.72J µg/L	
	Anions	Nitrate	0.211 mg/L	0.211J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	
BSB 2 PW PM	Total Metals	Copper	101 µg/L	101J µg/L	High duplicate RPD
		Zinc	1070 µg/L	1070J µg/L	
		Cobalt	3.09 µg/L	3.09J µg/L	High MS %R
		Iron	15400 µg/L	15400J µg/L	
		Lead	18.8 µg/L	18.8J µg/L	
	Anions	Nitrate	0.284 mg/L	0.284J mg/L	Missed holding time
		Nitrite	0.1U mg/L	R	
		Ortho-phosphate	0.1U mg/L	R	
BSB1 PW AM	Dissolved Metals	Chromium	3.47 µg/L	3.47U µg/L	Method blank contamination
		Calcium	34500 µg/L	34500J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	4590 µg/L	4590J µg/L	
		Potassium	3050 µg/L	3050J µg/L	

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
		Sodium	2290 µg/L	2290J µg/L	High MS %R
BSB1 PW PM	Dissolved Metals	Chromium	2.41 µg/L	2.41U µg/L	Method blank contamination
		Calcium	35200 µg/L	35200J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	4880 µg/L	4880J µg/L	
		Potassium	5980 µg/L	5980J µg/L	
		Sodium	2490 µg/L	2490J µg/L	High MS %R
DE2 PW PM	Dissolved Metals	Chromium	3.56 µg/L	3.56U µg/L	Method blank contamination
		Calcium	69400 µg/L	69400J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	9800 µg/L	9800J µg/L	
		Potassium	7290 µg/L	7290J µg/L	
		Sodium	3920 µg/L	3920J µg/L	High MS %R
DE1 PW AM	Dissolved Metals	Calcium	54100 µg/L	54100J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	10200 µg/L	10200J µg/L	
		Potassium	7880 µg/L	7880J µg/L	
		Sodium	2000 µg/L	2000J µg/L	High MS %R
DE1 PW PM	Dissolved Metals	Chromium	3.79 µg/L	3.79U µg/L	Method blank contamination
		Calcium	52800 µg/L	52800J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	9210 µg/L	9210J µg/L	
		Potassium	5490 µg/L	5490J µg/L	
		Sodium	2040 µg/L	2040J µg/L	High MS %R
DE2 PW AM	Dissolved Metals	Chromium	2.56 µg/L	2.56U µg/L	Method blank contamination
		Calcium	46800 µg/L	46800J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	6360 µg/L	6360J µg/L	
		Potassium	6440 µg/L	6440J µg/L	
		Sodium	2040 µg/L	2040J µg/L	High MS %R
MSB 2 PW AM	Dissolved Metals	Chromium	2.62 µg/L	2.62U µg/L	Method blank contamination
		Calcium	29300 µg/L	29300J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	4950 µg/L	4950J µg/L	
		Potassium	5390 µg/L	5390J µg/L	
		Sodium	1520 µg/L	1520J µg/L	High MS %R
MSB 2 PW PM	Dissolved Metals	Chromium	2.45 µg/L	2.45U µg/L	Method blank contamination
		Calcium	29100 µg/L	29100J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	4870 µg/L	4870J µg/L	
		Potassium	3880 µg/L	3880J µg/L	
		Sodium	1520 µg/L	1520J µg/L	High MS %R
MSB 1 PW PM	Dissolved Metals	Chromium	2.58 µg/L	2.58U µg/L	Method blank contamination
		Calcium	27500 µg/L	27500J µg/L	High MS and/or MSD
		Magnesium	7000 µg/L	7000J µg/L	

Sample ID	Parameter	Analyte	Reported Result	Qualified Result	Reason
		Potassium	2580 µg/L	2580J µg/L	%R; High MS/MSD RPD
		Sodium	2150 µg/L	2150J µg/L	High MS %R
MSB 1 PW AM	Dissolved Metals	Chromium	2.27 µg/L	2.27U µg/L	Method blank contamination
		Calcium	23000 µg/L	23000J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	5550 µg/L	5550J µg/L	
		Potassium	8420 µg/L	8420J µg/L	
		Sodium	1770 µg/L	1770J µg/L	High MS %R
UDE-PW-02-PM	Dissolved Metals	Chromium	3.42 µg/L	3.42U µg/L	Method blank contamination
		Calcium	28500 µg/L	28500J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	7960 µg/L	7960J µg/L	
		Potassium	7190 µg/L	7190J µg/L	
		Sodium	1770 µg/L	1770J µg/L	High MS %R
UDE-PW-02-AM	Dissolved Metals	Chromium	2.52 µg/L	2.52U µg/L	Method blank contamination
		Calcium	28900 µg/L	28900J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	8440 µg/L	8440J µg/L	
		Potassium	3760 µg/L	3760J µg/L	
		Sodium	361 µg/L	361J µg/L	High MS %R
UDE-PW-01-AM	Dissolved Metals	Chromium	2.59 µg/L	2.59U µg/L	Method blank contamination
		Calcium	25300 µg/L	25300J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	6140 µg/L	6140J µg/L	
		Potassium	4330 µg/L	4330J µg/L	
		Sodium	383 µg/L	383J µg/L	High MS %R
UDE-1 PW PM	Dissolved Metals	Chromium	2.83 µg/L	2.83U µg/L	Method blank contamination
		Calcium	27700 µg/L	27700J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	6300 µg/L	6300J µg/L	
		Potassium	2740 µg/L	2740J µg/L	
		Sodium	378 µg/L	378J µg/L	High MS %R
BSB 2 PW AM	Dissolved Metals	Chromium	1.95 µg/L	1.95U µg/L	Method blank contamination
		Calcium	18800 µg/L	18800J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	4430 µg/L	4430J µg/L	
		Potassium	1410 µg/L	1410J µg/L	
		Sodium	1810 µg/L	1810J µg/L	High MS %R
BSB 2 PW PM	Dissolved Metals	Chromium	2.14 µg/L	2.14U µg/L	Method blank contamination
		Calcium	17400 µg/L	17400J µg/L	High MS and/or MSD %R; High MS/MSD RPD
		Magnesium	4100 µg/L	4100J µg/L	
		Potassium	3420 µg/L	3420J µg/L	
		Sodium	320 µg/L	320J µg/L	High MS %R

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