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SAMPLING AND ANALYSIS PLAN FOR PRE DESIGN GROUNWATER SAMPLING AT LOWER SUBASE NSB NEW LONDON CT

4/1/2010

TETRA TECH

Sampling and Analysis Plan

UFP-SAP for Pre-Design Groundwater Sampling at Lower Subase

for

Naval Submarine Base New London

Groton, Connecticut

Naval Facilities Engineering Command Mid-Atlantic

Contract Number N62470-08-D-1001

Contract Task Order WE24

April 2010

SAP Worksheet #1 -- Title and Approval Page
(UFP-QAPP Manual Section 2.1)

FINAL
SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)
April 15, 2010

UFP-SAP for Pre-Design Groundwater Sampling at Lower Subase
Naval Submarine Base - New London
Groton, Connecticut

Prepared for:
Naval Facilities Engineering Command
Mid-Atlantic
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Prepared under:
Contract No. N62470-08-D-1001
Contract Task Order WE24

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Tom Johnston

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NAVFAC QAO/Chemist

Approval Signature: 4/15/10
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Corey A. Rich

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NAVFAC Remedial Project Manager
Jim Gravette

Approval Signature:
EPA Region 1 Remedial Project Manager
Kymberlee Keckler

Approval Signature: April 15 2010
CTDEP Environmental Analyst 3
Mark Lewis

EXECUTIVE SUMMARY

This Uniform Federal Policy (UFP)-Sampling and Analysis Plan (SAP) describes the investigation designed to collect additional groundwater samples from select monitoring wells in the Lower Subase at Naval Submarine Base – New London located in Groton, Connecticut. The UFP-SAP was prepared by Tetra Tech NUS, Inc. (Tetra Tech) on behalf of Naval Facilities Engineering Command Mid-Atlantic under Contract Number N62467-08-D-1001, Contract Task Order WE24. The field investigation described herein will be conducted to collect additional groundwater data that will be used to confirm the presence and extent of select metals in the groundwater of four zones of investigation (Zones 1, 4, 5, and 7) in the Lower Subase. Each of these zones include one or more sites that are being investigated under the Navy's Installation Restoration Program (IRP). Sites 10 and 11 are in Zone 1, Sites 13 and 19 are in Zone 4, Site 22 is in Zone 5, and Site 25 is in Zone 7. The data will be used to validate the zone-specific remedies selected for groundwater in the Lower Subase Feasibility Study and if necessary used during the development of the Lower Subase remedial design work plan for groundwater.

Multiple rounds of groundwater sampling have been conducted at monitoring wells in the seven Lower Subase zones during previous investigations; however, elevated detection limits for select metals in the historical data for four zones indicated that matrix interferences may have impacted the laboratory's ability to detect and quantify target analytes at all concentrations of concern. The potential for interferences resulted in there being limited acceptance by the regulators of the conclusions of the historical investigations. Low-flow sampling techniques and appropriate analytical methods will be used during the additional sampling efforts to minimize matrix interferences and attain appropriate detection limits. In addition, two rounds of samples will be collected under two different hydrologic regimes and low tide because these conditions may impact the detection of the metals. The new data will help to delineate the extent of contamination in the four zones. Until demonstrated otherwise, preparation of the Lower Subase Feasibility Study will continue under the assumption that treatment alternatives need to be considered for arsenic, copper, and lead in groundwater. Results from the first round of additional groundwater sampling will be used to provide preliminary judgment regarding this assumption.

The environmental question being addressed by this UFP-SAP is the following:

- Are select metals (arsenic, copper, and lead) present in the groundwater of Zones 1, 4, 5 and 7 at concentrations that exceed the Connecticut Department of Environmental Protection's (CTDEP's) surface water protection criteria (SWPC) or alternative SWPC as allowed under the Remediation Standard Regulations (RSRs).

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ACRONYMS

bgs	below ground surface
CA	Corrective Action
CAS	Columbia Analytical Services, Inc.
CCB	Continuing Calibration Blank
CCV	Continuing Calibration Verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CSM	Conceptual Site Model
CTDEP	Connecticut Department of Environmental Protection
CTO	Contract Task Order
CVAA	Cold Vapor Atomic Adsorption
DQI	Data Quality Indicator
DQO	Data Quality Objective
DVM	Data Validation Manager
EDD	Electronic Data Deliverable
EE/CA	Engineering Evaluation/Cost Analysis
EPA	Environmental Protection Agency
FOL	Field Operations Leader
FS	Feasibility Study
FTMR	Field Task Modification Request
GC	Gas Chromatograph
GC/ECD	Gas Chromatograph/Electron Capture Detector
GC/MS	Gas Chromatograph/Mass Spectrometer
GPS	Global Positioning System
HASP	Health and Safety Plan
HSM	Health and Safety Manager
HSO	Health and Safety Officer
ICB	Initial Calibration Blank
ICP	Inductively Coupled Plasma
IDL	Instrument Detection Limit
IRCDQM	Installation Restoration Chemical Data Quality Manual
LCS	Laboratory Control Sample
LIMS	Laboratory Information Management Systems
MDL	Method Detection Limit
MPC	Measurement Performance Criterion
MS	Matrix Spike

MSD	Matrix Spike Duplicate
msl	mean sea level
NAD	North American Datum
NAVFAC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NSB-NLON	Naval Submarine Base – New London
NTCRA	Non-Time-Critical Removal Action
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAH	Polynuclear Aromatic Hydrocarbon
PAL	Project Action Limit
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	Polychlorinated Biphenyl
PHSO	Project Health and Safety Officer
PM	Project Manager
POC	Point of Contact
PRG	Preliminary Remediation Goal
PT	Proficiency Testing [previously known as performance evaluation (PE) sample]
QA	Quality Assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
QL	Quantitation Limit
%R	Percent Recovery
RCRA	Resource Conservation and Recovery Act
RCSA	Regulations of Connecticut State Agencies
RI	Remedial Investigation
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RSD	Relative Standard Deviation
RSR	Remediation Standard Regulations
RT	Retention Time
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SMO	Site Management Office
SOP	Standard Operating Procedure
SPLP	Synthetic Precipitate Leaching Procedure

SQLs	Structured Query Language
SSO	Site Safety Officer
SVOA	Semivolatile Organic Analyte
SVOC	Semivolatile Organic Compound
SWPC	Surface Water Protection Criteria
TBD	To Be Determined
TCLP	Toxicity Characteristic Leaching Procedure
UFP	Uniform Federal Policy

SAP Worksheet #2 -- SAP Identifying Information
(UFP-QAPP Manual Section 2.2.4)

Site Name/Number: Sites 10 and 11 (Zone 1), Sites 13 and 19 (Zone 4), Site 22 (Zone 5), and Site 25 (Zone 7)
Operable Unit: OU4
Contractor Name: Tetra Tech NUS, Inc.
Contract Number: N62470-08-D-1001
Contract Title: Navy CLEAN
Work Assignment Number (optional): CTO WE24

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of the Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP) (EPA, 2005) and EPA Guidance for Quality Assurance Project Plans, EPA QA/G-5, QAMS (2002). Identify any additional guidance used to prepare SAP: None

2. Identify regulatory program: CERCLA for site groundwater investigation.

3. This SAP is a project-specific SAP.

4. List dates of scoping sessions that were held:

Scoping Session	Date
Partnering Meeting conducted with Navy, EPA, CTDEP, and Tetra Tech NUS, Inc. – Groundwater data reviewed and need for sampling effort discussed by team.	March 16, 2009
Conference call conducted with Navy, CTDEP, and Tetra Tech NUS, Inc. – Need for sampling effort discussed by team.	April 02, 2009
Partnering Meeting conducted with Navy, EPA, CTDEP, and Tetra Tech NUS, Inc. – Scope of sampling effort discussed by team.	May 14, 2009
Conference call conducted with Navy, CTDEP, and Tetra Tech NUS, Inc. – Scope of sampling effort discussed and finalized by team.	May 20, 2009
DQO development session – Informal session designed to finalize decisions that are documented in this SAP	June 30, 2009

5. List dates and titles of any SAP documents written for previous site work that are relevant to the current investigation.

Title	Date
Lower Subase Remedial Investigation Report by Tetra Tech NUS, Inc.	January 1999
Draft Lower Subase Feasibility Study Report by Tetra Tech NUS, Inc.	March 2008

6. List organizational partners (stakeholders) and connection with lead organization:
EPA (regulatory oversight), CTDEP (regulatory oversight), and NAVFAC Mid-Atlantic (property owner).

7. Lead organization (see Worksheet #7 for detailed list of data users) NAVFAC Mid-Atlantic

- If any required SAP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:

Cross-walk omitted, not needed.

SAP Worksheet #3 -- Distribution List
(UFP-QAPP Manual Section 2.3.1)

Name of SAP Recipient	Title/Role	Organization	Telephone Number (Optional)	E-Mail Address or Mailing Address	Document Control Number (Optional)
James Gravette	NAVFAC Remedial Project Manager (RPM)/ Responsible for project execution	NAVFAC Mid-Atlantic	757-444-0735	james.gravette@navy.mil	NA
Richard Conant	Environmental Restoration Program Manager/Base Contact	NSB-NLON	860-694-5649	richard.conant@navy.mil	NA
Bonnie Capito	Administrative Record/Librarian	NAVFAC Atlantic	757-322-4785	Bonnie.capito@navy.mil	NA
Kymberlee Keckler	RPM/Approves SAP prior to implementation	EPA Region 1	617-918-1385	Keckler.Kymberlee@epamail.epa.gov	NA
Mark Lewis	Environmental Analyst 3/Approves SAP prior to implementation	CTDEP	860-424-3768	mark.lewis@po.state.ct.us	NA
Corey Rich	Base Coordinator/ Project Manager (PM)/Responsible for project management and execution	Tetra Tech	412-921-8984	corey.rich@tetratech.com	NA
Dr. Tom Johnston	CLEAN Contract QA Manager/ Responsible for overall contract QA	Tetra Tech	412-921-8615	tom.johnston@tetratech.com	NA

Name of SAP Recipient	Title/Role	Organization	Telephone Number (Optional)	E-Mail Address or Mailing Address	Document Control Number (Optional)
Joe Samchuck	Data Validation Manager/ Manages validation activities	Tetra Tech	412-921-8510	joseph.samchuck@tetratech.com	NA
Lee Leck	Data Manager/ Manages electronic data	Tetra Tech	412-921-8856	lee.leck@tetratech.com	NA
Jim Ferguson	Field Operations Leader (FOL)/Site Safety Officer(SSO)/ Field operations management and safety oversight	Tetra Tech	412-920-7022	james.ferguson.tetratech.com	NA
Leanne Ganser	Project Chemist/ Technical support and Tetra Tech liaison with laboratory	Tetra Tech	412-921-8148	leanne.ganser@tetratech.com	NA
Todd Finlayson	EPA Contractor/ Technical support	Gannett Fleming	TBD	rtfinlayson@gfnet.com	NA
Lynda Huckestein	Client Services Manager/ Project management	Columbia Analytical Services, Inc. (CAS)	360-577-7222	lhuckestein@caslab.com	NA

Each person in this table will be responsible for distributing copies of this SAP to appropriate personnel within their organization. For example, the Tetra Tech PM will be responsible for distributing copies of this SAP to all project personnel listed in Worksheet #4 (Project Personnel Sign-Off Sheet)

SAP Worksheet #4 -- Project Personnel Sign-Off Sheet
(UFP-QAPP Manual Section 2.3.2)

Key personnel will be instructed to read the SAP prior to attending an internal site-specific kick-off meeting for field activities. The Tetra Tech PM will track when the reviews have been completed, obtain signatures, and ensure that the completed sign-off sheet is included in the central project file.

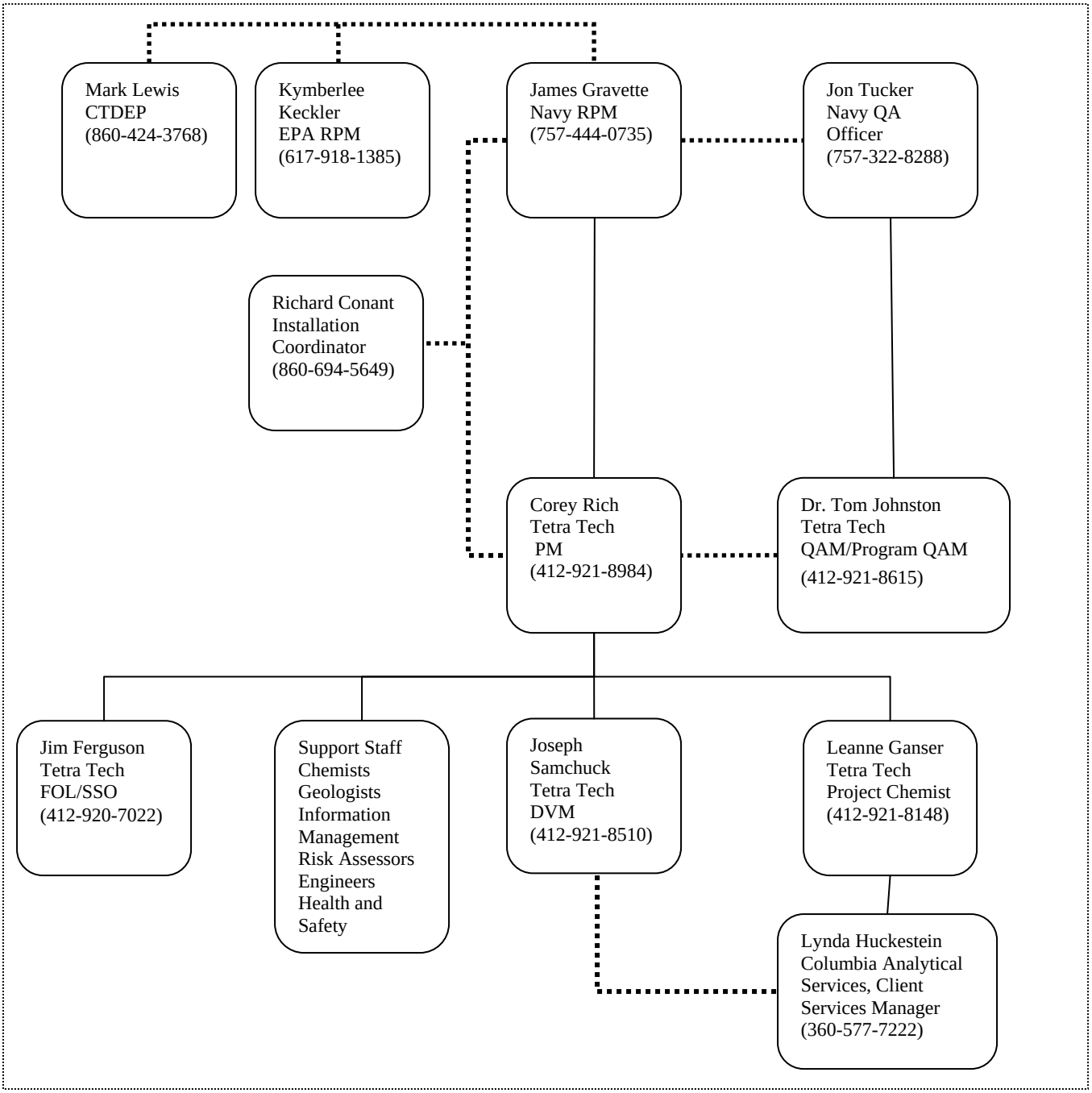
Name	Organization/Title/Role	Telephone Number (optional)	Signature/E-Mail Receipt	SAP Section Reviewed	Date SAP Read
Corey Rich	Tetra Tech/PM/Responsible for project management and execution	412-921-8984		All	
Jim Ferguson	Tetra Tech/FOL and SSO/ Field operations management and safety oversight	412-920-7022		All	
Jennifer Carothers	Tetra Tech/Project Health and Safety Officer (PHSO)/Preparation of Health and Safety Plan	412-921-8083		Worksheet #s 10, 11, 14 and Health and Safety Plan (HASP)	
Leanne Ganser	Tetra Tech/Project Chemist/ Technical support and Tetra Tech liaison with laboratory	412-921-8148		All	
Dr. Tom Johnston	Tetra Tech/Quality Assurance Manager (QAM)/ Responsible for overall contract QA	412-921-8615		All	
Joseph Samchuck	Tetra Tech/Data Validation Manager (DVM)/ Manages validation activities	412-921-8510		Worksheet #s 12, 14, 15, 19, 20, 23-28, 30, 34-37	
Lee Leck	Tetra Tech/Data Manager/ Manages electronic data	412-921-8856		Worksheet #s 12, 14, 15, 19, 20, 23-28, 30, 34-37	

Name	Organization/Title/Role	Telephone Number (optional)	Signature/E-Mail Receipt	SAP Section Reviewed	Date SAP Read
Lynda Huckestein	Columbia Analytical Services/Client Services Manager/ Project management	360-577-7222		Worksheet #s 12, 14, 15, 19, 20, 23-28, 30, 34-37	

SAP Worksheet #5 -- Project Organizational Chart

(UFP-QAPP Manual Section 2.4.1)

Lines of Authority ————
Lines of Communication ·····



SAP Worksheet #6 -- Communication Pathways
(UFP-QAPP Manual Section 2.4.2)

Communication Driver	Responsible Affiliation	Name	Phone Number and/or E-Mail	Procedure
QAPP amendments	Tetra Tech PM NAVFAC RPM	Corey Rich James Gravette	412-921-8984 757-444-0735	After realizing an amendment is needed, PM will send NAVFAC a concurrence letter within 7 days. The NAVFAC RPM will sign the letter within 5 days of receipt.
Schedule changes	Tetra Tech PM	Corey Rich	412-921-8984	When impact is realized, PM will send NAVFAC a schedule concurrence letter within 7 days or prior to the first affected deliverable date.
Field issues that require changes in scope or implementation of field work	Tetra Tech FOL NAVFAC RPM Tetra Tech PM	Jim Ferguson James Gravette Corey Rich	412-920-7022 757-444-0735 412-921-8984	FOL informs PM the day the issue is realized. PM informs the NAVFAC RPM of the issue within 1 day of the FOL's notification. PM also sends a concurrence letter to the NAVFAC within 7 days if project scope is affected. The NAVFAC RPM will sign the letter within 5 days of receipt. Document changes on a Field Task Modification Request (FTMR) form.
Stop work recommendations, for example, to protect workers from unsafe conditions/situations or to prevent a degradation in quality of work	Tetra Tech FOL/SSO Tetra Tech PM Tetra Tech QAM	Jim Ferguson Corey Rich Dr. Tom Johnston	412-920-7022 412-921-8984 412-921-8615	On the day the problem is identified, FOL, SSO, or QAM informs PM and documents problem on a FTMR. On the same day of the notification from the FOL, PM informs NAVFAC RPM and Installation Coordinator.
Field or laboratory data quality deficiencies or concerns	Laboratory Client Services Manager Tetra Tech Project Chemist	Lynda Huckestein Leanne Ganser	360-577-7222 412-921-8148	When issue is related to chemical data, Laboratory Client Services Manager notifies Project Chemist within 2 days of identification of problem. Project Chemist notifies Tetra Tech PM within 1 day.

SAP Worksheet #7 -- Personnel Responsibilities and Qualifications Table
(UFP-QAPP Manual Section 2.4.3)

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Corey Rich	PM/Responsible for project management and execution	Tetra Tech	Oversees project, financial, schedule, and technical day-to-day management of the project. Specific responsibilities: • Ensures timely resolution of project-related technical, quality, and safety questions associated with Tetra Tech operations. • Functions as the primary Tetra Tech interface with the NAVFAC RPM, regulators, Tetra Tech field and office personnel, and laboratory points of contact. • Ensures that Tetra Tech health and safety issues related to this project are communicated effectively to all personnel and off-site laboratories. • Monitors and evaluates all Tetra Tech subcontractor performance. • Coordinates and oversees work performed by Tetra Tech field and office technical staff (including data interpretation and report preparation). • Coordinates and oversees maintenance of all Tetra Tech project records.	B.A., Physics, B.S., Civil Engineering, 18 years environmental experience

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
			• Coordinates and oversees review of Tetra Tech project deliverables. • Prepares and issues final Tetra Tech deliverables to NAVFAC.	
Jim Ferguson	FOL/ Field operations management	Tetra Tech	Supervises, coordinates, and performs field sampling activities. Specific responsibilities: • Functions as the on-site communications link between field staff members, subcontractors, and Tetra Tech PM. • Oversees mobilization and demobilization of all field equipment and subcontractors. • Coordinates and manages the field technical staff. • Adheres to work schedules provided by the Tetra Tech PM. • Ensures proper maintenance of site logbooks, field logbooks, and field recordkeeping. • Initiates FTMRs (field change orders) when necessary. • Identifies and resolves problems in the field, implements and documents corrective action (CA) procedures, and provides communication between the field team and project	GS, Geology, 23 years environmental experience

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
			management. Alerts off-site analytical laboratories of any special health and safety hazards associated with environmental samples. • Ensures that all health and safety requirements for the investigation are implemented. • Alerts off-site analytical laboratories of any special health and safety hazards associated with environmental samples. • FOL responsibilities include initiating and conducting equipment inventories to ensure equipment is available, purchasing equipment as required, staging equipment for efficient loading and transport from the Tetra Tech office to the site, and, after field activities are completed, demobilizing the equipment.	
Jim Ferguson	SSO/Safety oversight	Tetra Tech	The SSO will be responsible for training and monitoring site conditions. Details of these responsibilities are presented in the HASP and include: • Controlling specific health and safety-related field operations such as personnel decontamination, monitoring of worker heat or cold stress, and	BS, Geology, 23 years environmental experience

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
			distribution of safety equipment. • Conducting and documenting a daily health and safety briefing each day while on site. • Assuring that field personnel comply with all procedures established in the HASP. • Identifying SSOs in their absence. • Terminating work if an imminent safety hazard, emergency situation, or other potentially dangerous situation is encountered. • Ensuring the availability and condition of health and safety monitoring equipment. • Coordinating with the FOL and Tetra Tech PM to institute and document any necessary HASP modifications. • Ensuring that facility personnel and subcontractors are adequately advised and kept clear of potentially contaminated materials.	
Dr. Tom Johnston	QAM/Responsible for overall contract QA	Tetra Tech	Reviews the SAP, oversees preparation of lab scope, and conducts data quality reviews. Ensures that quality aspects of the CLEAN program are implemented. Specific responsibilities:	Ph.D. Analytical Chemistry, 32 years environmental experience

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
			• Develops, maintains, and monitors QA policies and procedures. • Provides training to Tetra Tech staff in quality assurance (QA)/quality control (QC) policies and procedures. • Conducts systems and performance audits to monitor compliance with environmental regulations, contractual requirements, SAP requirements, and corporate policies and procedures. • Audits project records. • Monitors subcontractor quality controls and records. • Assists in the development of CA plans and ensuring correction of non-conformances reported in internal or external audits. • Ensures that this SAP meets Tetra Tech, Navy, and EPA QA requirements. • Prepares QA reports for management.	

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Joseph Samchuck	DVM/Manages validation activities	Tetra Tech	Manages data validation activities within Tetra Tech, including: • Ensuring the QA of data validation deliverables. • Providing technical advice on data usability. • Coordinating and maintaining data validation review schedule.	MBA, M.S. Finance, B.S. Chemistry, 24 years environmental experience
Leanne Ganser	Project Chemist/Technical support and Tetra Tech liaison with laboratory	Tetra Tech	Provides support to the project including: • Assisting in preparation of SAP. • Preparing laboratory scopes of work, coordinates analyses with laboratory chemists, ensures that the laboratory scope of work is followed, and communicates with Tetra Tech staff. • Providing technical advice to the Tetra Tech team on matters of project chemistry. • Reviewing laboratory data. • Evaluating data usability. • Functioning as the primary interface between the subcontracted laboratory and Tetra Tech staff.	M.S., Environmental Science, 4 years environmental experience

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Lynda Huckestein	Client Services Manager/Project management	CAS	Coordinates analyses with lab chemists, ensures that the scope of work is followed, provides QA of data packages, and communicates with Tetra Tech project staff.	Can be provided upon request

SAP Worksheet #8 -- Special Personnel Training Requirements Table

(UFP-QAPP Manual Section 2.4.4)

All field personnel will have appropriate training to conduct the field activities to which they are assigned. Additionally, each site worker will be required to have completed a 40-hour course (and 8-hour refresher, if applicable) in health and safety training as described under Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120(b)(4). Safety requirements are addressed in greater detail in the accompanying TtNUS HASP included under separate cover.

SAP Worksheet #9 -- Project Scoping Session Participants Sheet
(UFP-QAPP Manual Section 2.5.1)

Project Name: Additional Groundwater Sampling for Metals in Zones 1, 4, 5, and 7 Projected Date(s) of Sampling: April 2010 and September 2010 Project Manager: Corey Rich	Site Name: Lower Subase Groundwater at NSB-NLON Site Location: Groton, Connecticut

Date of Session: May 20, 2009
Scoping Session Purpose: Determine Scope of Project

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Corey Rich	Project Manager	Tetra Tech NUS, Inc.	412-921-8984	corey.rich@tetratech.com	Project Management
Jim Gravette	RPM	Navy	757-444-0735	jim.gravette@navy.mil	RPM
Richard Conant	Environmental Restoration Program Manager	Navy	860-694-5649	richard.conant@navy.mil	Base Point of Contact
Mark Lewis	Environmental Analyst 3	CTDEP	860-424-3768	mark.lewis@ct.gov	Regulatory Review
Rosemary Gatter-Evarts	Environmental Analyst-Aquatic Toxicity Program	CTDEP	860-424-3732	Rosemary.Gatter-Evarts@ct.gov	Regulatory Review
Bill Warzecha	Supervisor-Remediation Division, Eastern District	CTDEP	860-424-3776	William.Warzecha@ct.gov	Regulatory Review
Nina Balsamo	Civil Engineer	Tetra Tech	412-921-8132	nina.balsamo@tetratech.com	Project Engineer

Decisions on the scope of the groundwater sampling at the Lower Subase were captured in the minutes from the May 20, 2009 conference call which are provided in Appendix E.

Project Name: Additional Groundwater Sampling for Metals in Zones 1, 4, 5, and 7 Projected Date(s) of Sampling: April 2010 and September 2010 Project Manager: Corey Rich	Site Name: Lower Subase Groundwater at NSB-NLON Site Location: Groton, Connecticut

Date of Session: June 30, 2009 **Scoping Session Purpose: Determine DQOs for the Project**					
Name	**Title**	**Affiliation**	**Phone #**	**E-mail Address**	**Project Role**
Corey Rich	Project Manager	Tetra Tech NUS, Inc.	412-921-8984	corey.rich@tetratech.com	Project Management
Peggy Churchill	Environmental Scientist III	Tetra Tech NUS, Inc.	321-636-1300	peggy.churchill@tetratech.com	DQO Specialist
Shannon Hill	Geologist	Tetra Tech NUS, Inc.	412-921-8876	shannon.hill@tetratech.com	Project Geologist

Decisions on the groundwater sampling DQOs at the Lower Subase are captured in this UFP-SAP. No formal minutes were prepared for the June 30, 2009 DQO meeting.

SAP Worksheet #10 -- Conceptual Site Model
(UFP-QAPP Manual Section 2.5.2)

10.1 SITE DESCRIPTION

10.1.1 Facility Background

NSB-NLON is located in southeastern Connecticut in the Towns of Ledyard and Groton and is situated on the eastern bank of the Thames River, approximately 6 miles north of Long Island Sound (Figure 10-1). The Navy's use of the Thames River shoreline at NSB-NLON began in 1868, but most of the construction along the river at NSB-NLON took place in the early 1900s, with a major expansion from 1935 to 1940. NSB-NLON currently provides base command for Naval submarine activities in the Atlantic Ocean and as part of these activities supports submarine training facilities, military offices, medical facilities, and facilities for submarine maintenance, repair, and overhaul.

The Lower Subase contains piers and berths for submarine docking; facilities for submarine maintenance, repair, and overhaul; and administrative buildings (Figure 10-2). Battery overhaul was one of the largest operations at the Lower Subase prior to the advent of nuclear-powered submarines. Lead-acid battery maintenance and overhaul activities were conducted in this area until the mid-1950s. A classified materials incinerator was also operated in the Lower Subase until 1967. It is possible that the resulting ash was disposed in portions of the Lower Subase. Petroleum products were used by the Navy throughout the Lower Subase. Releases of petroleum products to the environment may have occurred because of leaks from subsurface storage tanks and fuel distribution lines, vehicle and locomotive maintenance operations and associated waste disposal practices, and marine fueling activities. Other ship and submarine maintenance activities (e.g., painting) were also conducted in the Lower Subase and adjacent Thames River.

10.1.2 Lower Subase

The Lower Subase at NSB-NLON has been designated as Operable Unit (OU) 4. Under the IRP, the Navy designated seven separate zones for investigation at the Lower Subase. The soil and groundwater in the zones were studied during various investigations [1991 Phase 1 Remedial Investigation (RI), 1993 Pier 33/Berth 16 Site Inspection, 1994 Phase 2 RI, and 1997 Lower Subase RI]. The zones and associated IRP sites are shown on Figure 10-2.

The groundwater at Zones 1, 4, 5, and 7 is the focus of this SAP. Evaluations of available data completed during the Lower Subase Feasibility Study showed that arsenic, copper, and/or lead were reported at concentrations greater than applicable CTDEP SWPC and Alternative SWPC. In addition, for several sampling rounds, the analytical detection limits for arsenic were greater than the Alternative SWPC. The evaluation focused on wells with criteria exceedances and wells closest to the adjacent Thames River to determine concentrations closest to the discharge point. In addition, lead was identified as a potential soil to groundwater contaminant of concern. Concentrations of lead in soil that are greater

than mobility criteria have been identified in the Lower Subase zones. The same evaluations showed that arsenic, copper, and lead were not reported at concentrations greater than applicable SWPC and Alternative SWPC and/or there were no elevated detection limits for Zones 2, 3, or 6; therefore, groundwater at these zones are not included in this SAP.

Development and selection of appropriate SWPC were completed in the Lower Subase Feasibility Study. To comply with CTDEP recommendations, Alternative SWPC, developed using a dilution factor of 100, were selected for the Lower Subase, with the exception of Zone 1 and arsenic in all zones. For copper in Zone 1, CTDEP ruled that use of the Alternative SWPC (310 µg/L) is not allowable because of past reported elevated concentrations of copper in the surface water discharge from the power plant located in that zone. Instead, the standard SWPC (48 µg/L) was selected for copper in Zone 1. For arsenic, CTDEP promulgated a site-specific Alternative SWPC (10 µg/L) for all zones. For lead, the Alternative SWPC was calculated as 810 µg/L and this Alternative SWPC is applicable for all zones. However, the standard lead SWPC (13 µg/L) was also retained for consideration to ensure appropriate detection limits are selected for the project.

10.1.2.1 Zone 1

Zone 1 includes Site 10 (Fuel Storage Tanks and Tank 54-H), Site 11 (Power Plant Oil Tanks), and Building 89 Underground Storage Tank (UST). Historical leaks from USTs at Sites 10 and 11 and fuel distribution lines in Zone 1 were the known sources of contamination. The Power Plant in Zone 1 withdraws water from the adjacent Thames River for cooling and discharges it back to the river. The river water use is regulated by CTDEP under a National Pollution Discharge Elimination System (NPDES) permit.

Zone 1 is underlain by up to 20 feet of sand and gravel backfill, and the unconfined water table occurs within the backfill at depths ranging from 4 to 10 feet below ground surface (bgs). Figure 10-3 shows the locations of geological cross-sections through Zones 1, 4, 5, and 7. Figure 10-4 depicts a geologic cross section through Zone 1.

Various metals were reported in Zone 1 soil. The maximum concentrations of the contaminants of concern for this SAP (arsenic, copper, and lead) that were reported in surface or subsurface soil were 12.3 mg/kg, 64.5 mg/kg, and 383 mg/kg, respectively. The potential for movement of contaminants from soil to groundwater was identified for lead. The potential mobility of lead was identified through screening the results of testing by the Toxicity Characteristic Leaching Procedure (TCLP) against CTDEP criteria.

Arsenic, copper, and lead were reported in Zone 1 groundwater samples (see Table 10-1). Maximum total concentrations of arsenic, copper, and lead reported in Zone 1 wells were 16.8 µg/L, 156 µg/L, 55.7 µg/L, respectively, and maximum dissolved concentrations were 24.8 µg/L, 120 µg/L, and 36.3 µg/L, respectively.

Four groundwater sampling events (1991 Phase 1 RI, 1994 Phase 2 RI - Rounds 2-1 and 2-2, and 1997 Lower Subase RI) were performed in Zone 1. Total and dissolved arsenic concentrations reported in the two wells closest to the Thames River (13MW19 and 13MW21) were greater than the Alternative SWPC during one event. These elevated arsenic concentrations (13.9 µg/L total and 24.8 µg/L dissolved in 13MW19 and 16.8 µg/L total and 12.8 µg/L dissolved in 13MW21) were reported during Round 1 of the 1994 Phase 2 RI. Analytical data from subsequent sampling rounds did not detect arsenic at concentrations greater than the Alternative SWPC. Total and dissolved arsenic concentrations (12.4 µg/L and 11.3 µg/L) were reported in well 13MW20 during the Lower Subase RI at concentrations greater than the Alternative SWPC, but arsenic was not reported at concentrations greater than the Alternative SWPC during the two Phase 2 RI sampling rounds.

During the four Zone 1 groundwater sampling events, the total copper concentrations reported in 2 of the 4 wells closest to the Thames River (13MW19 and 13MW21) were greater than the SWPC during one event. The elevated concentrations (68.4 µg/L in 3MW19 and 53.3 µg/L in 13MW21) were reported during Round 1 of the 1994 Phase 2 RI. However, dissolved copper concentrations reported in these wells during the same sampling event (44.2 µg/L in 13MW19 and 20.6 µg/L in 13MW21) were less than the SWPC and total and dissolved copper concentrations in these wells during subsequent sampling events were less than the SWPC. Total and dissolved copper concentrations (156 µg/L and 120 µg/L) were reported in well 13MW20 during the Lower Subase RI at concentrations greater than the SWPC, but copper was not reported at concentrations greater than the SWPC during the two Phase 2 RI sampling rounds. The total copper concentration (77.9 µg/L) reported in well FOMW14 during the Lower Subase RI was greater than the SWPC, but the dissolved concentration (14.8 µg/L) was less than the SWPC.

The total lead concentrations reported in 2 of the 4 wells closest to the Thames River (13MW19 and 13MW21) were greater than the SWPC during the four Zone 1 groundwater sampling events. An elevated concentration of lead (39.3 µg/L) was only reported in 13MW19 during Round 1 of the 1994 Phase 2 RI. The dissolved lead concentration reported in this well during the same sampling event (12.8 µg/L) was less than the SWPC. Total and dissolved lead concentrations reported in well 13MW21 during Round 1 of the 1994 Phase 2 RI (36.1 µg/L and 13.5 µg/L) and 1997 Lower Subase RI (27.4 µg/L and 21.9 µg/L) were greater than the SWPC. However, lead concentrations reported in this well during Round 2 of the 1994 Phase 2 RI were below the SWPC. Total and dissolved lead concentrations (55.7 µg/L and 36.3 µg/L) were reported in well 13MW20 during the Lower Subase RI at concentrations greater than the alternative SWPC, but lead was not reported at concentrations greater than the alternative SWPC during the two Phase 2 RI sampling rounds. The total lead concentration (36.8 µg/L) reported in well FOMW14 during the Lower Subase RI was greater than the SWPC, but the dissolved concentration (2.4 µg/L) was less than the SWPC.

Potential matrix inferences (turbidity) may have impacted the Zone 1 analytical results. As shown in Table 10-2, groundwater samples collected from wells 13MW19 and 13MW21 during Round 1 of the

Phase 2 RI had elevated turbidity [26 and 43 nephelometric turbidity units (NTUs), respectively], which is likely to bias high the reported concentrations of metals in groundwater.

10.1.2.2 Zone 4

Site 13 (Building 79 Waste Oil Pit), Site 19 (Solvent Storage Area, former Building 316), and the Quay Wall Study Area are located in Zone 4. Diesel engines were serviced at Site 13 (Building 79 Former Waste Oil Pit) in Zone 4 during the 1940s and 1950s, and the resulting waste oil and solvents were drained into a pit in the northwestern corner of the building. The pit was subsequently abandoned, but mapping showed a subsurface drainpipe extending from the pit to Albacore Road that could have allowed significant releases of the waste oil and solvents. This pit is suspected of being the primary source of contamination to Zone 4 media. Potential secondary sources of contamination were leaks from the former fuel distribution lines that ran throughout Zone 4 and releases from the former Battery Overhaul Shop at Site 17 in adjacent Zone 3.

The zone is underlain by up to 15 feet of sand and gravel fill material with some debris (brick fragments and fly ash). In the western part of Zone 4, a wooden pier and quay wall constructed in 1940 underlie Albacore Road. The unconfined water table occurs within the backfill at depths ranging from approximately 4 to 6 feet bgs. Figure 10-5 depicts a geologic cross section through Zone 4.

Arsenic and copper in soil were reported at maximum concentrations of 4.5 mg/kg and 147 mg/kg. Lead was reported at a maximum concentration of 10,600 mg/kg in surface soil and lead concentrations in subsurface soil ranged from 25.2 to 8,240 mg/kg. TCLP lead concentrations suggest that some of the lead in Zone 4 soil is leachable and could impact groundwater. However, SPLP lead concentrations were significantly less than reported TCLP lead concentrations, indicating that the mobility of lead is less than indicated by the TCLP results.

Arsenic, copper, and lead were reported in Zone 4 groundwater samples. Maximum total concentrations of arsenic, copper, and lead reported in Zone 4 wells were 29.6 µg/L (WE5), 649 µg/L (NESO11), 2,760 µg/L (NESO11), respectively, and maximum dissolved concentrations were 14.7 µg/L (13MW13), 20.4 µg/L (13MW16), and 14.1 µg/L (NESO11), respectively. Dissolved copper and lead concentrations in NESO11 (3.5 µg/L and 10.9 µg/L, respectively) were significantly less than the maximum total concentrations reported in Round 1 of the Phase 2 RI, suggesting that total copper and lead concentrations were impacted by suspended solids. As shown on Table 10-2, the turbidity in NESO11 during Round 1 of the Phase 2 RI was 221 NTU.

Arsenic groundwater data for Zone 4 wells are summarized in Table 10-1. In Zone 4, four groundwater sampling events were performed (1991 Phase 1 RI, 1994 Phase 2 RI Rounds 2-1 and 2-2, and 1997 Lower Subase RI) and the total arsenic concentrations reported in 2 of the 6 wells closest to the Thames River (13MW15 and NESO10) were slightly greater than the Alternative SWPC during one event. These

elevated concentrations of total arsenic (11 µg/L in 13MW15 and 19 µg/L in NESO10) were reported during Round 2 of the 1994 Phase 2 RI. In addition, the recorded analytical detection limit for arsenic was elevated (20 µg/L) for several of the samples collected in Zone 4 during the Phase 2 RI. Analytical data from previous and subsequent sampling events did not detect arsenic at concentrations greater than the Alternative SWPC. Wells 13MW13, NESO11, and WE5 also had detections of either total and/or dissolved arsenic concentrations greater than the Alternative SWPC. Typically the elevated concentrations were only reported during 1 or 2 of the four rounds of data collection.

As shown on Table 10-2, groundwater samples collected from wells 13MW14, 13MW15, and NESO10 had high salinity [17, 20.8, and 5.3 grams per liter (g/L), respectively] and high turbidity (16 NTUs in NESO10), both of which are likely to bias high the concentrations of metals in groundwater. Therefore, it is possible that the elevated arsenic concentrations reported during only one round of sampling and the elevated detection limits achieved during the Phase 2 RI may be the result of matrix interferences.

10.1.2.3 Zone 5

Site 22 (Pier 33/Building 175) is the only site in Zone 5. Building 175 was originally used to house several above-ground battery acid (sulfuric acid) storage tanks. The above-ground storage tanks and associated transfer piping were removed, and there were no known or reported spills from the system. Leaks from former USTs and associated piping to the north and south of Building 175 are potential sources of contamination reported in Zone 5.

The site is underlain by 5 to 15 feet of fill consisting of sand or sand and gravel. The unconfined water table lies within the backfill and underlying natural sand unit at a depth of approximately 4 feet bgs. Figure 10-6 depicts a geologic cross section through Zone 5.

Arsenic, copper, and lead were reported in soil at maximum concentrations of 3.5 mg/kg, 43.8 mg/kg, and 91.2 mg/kg, respectively. Reported TCLP lead concentrations suggested that some of the lead in Zone 5 soil is leachable and could impact groundwater, but subsequent sampling and analysis by SPLP suggest the mobility of lead is less than indicated by the TCLP results.

Arsenic, copper, and lead were reported in Zone 5 groundwater samples. Total arsenic was not reported in the samples. Maximum total concentrations of copper and lead reported in Zone 5 wells were 4.2 µg/L (19MW2) and 1.3 µg/L (19MW2), respectively. The maximum dissolved concentrations of arsenic, copper and lead were 34.3 µg/L (19MW4), 11.4 µg/L (19MW3), and 2.2 µg/L (19MW3), respectively.

Only the dissolved arsenic concentration reported in well 19MW4 (34.3 µg/L) during the 1993 Site Inspection was greater than the Alternative SWPC (see Table 10-1). The total concentration for this well was non-detect with an elevated detection limit (30.2 UW µg/L). No data are available regarding the

turbidity or salinity in this sample to determine if matrix interferences impacted the data. In addition, no subsequent sampling was performed at this well because it was destroyed.

10.1.2.4 Zone 7

Two sites, Site 21 (Berth 16 and Transformers at Building 157 Vault 31) and Site 25 (Classified Materials Incinerator) are located in Zone 7. Potential sources of contamination in Zone 7 included operation of a former Classified Materials Incinerator, disposal of the associated ash, leaks from former transformers, fuel distribution lines, and an UST, and disposal of waste materials to a former septic tank and leaching field that serviced Building 173.

Zone 7 is underlain by 6 to 16 feet of sand and gravel fill underlain by natural gravelly sand and gravel units to approximately 50 feet bgs. Some of the fill contains metal, brick, glass, plastic, concrete, and other types of debris. The depth to the unconfined water table varies from 3 to 6 feet bgs across Zone 7. Figure 10-7 depicts a geologic cross section through Zone 7.

Arsenic, copper, and lead were reported in soil at maximum concentrations of 50 mg/kg, 9,010 mg/kg, and 189,000 mg/kg, respectively. The maximum lead concentration was reported in subsurface soil and it was the highest concentration reported in soil in any of the other Lower Subase zones. TCLP lead concentrations suggested that some of the lead in Zone 7 subsurface soil is leachable and could impact groundwater, but subsequent sampling and analysis by Synthetic Precipitate Leaching Procedure (SPLP) suggest the mobility of lead is less than indicated by the TCLP results.

Arsenic, copper, and lead were reported in Zone 7 groundwater samples. Maximum total concentrations of arsenic, copper, and lead reported in Zone 7 wells were 18.8 µg/L, 24.4 µg/L, and 117 µg/L, respectively. The maximum dissolved concentrations of arsenic, copper, and lead were 20 µg/L, 21.1 µg/L, and 97.5 µg/L, respectively. The highest dissolved concentration of lead (97.5 µg/L) was reported in a monitoring well located near Building 456. Lead was reported at elevated concentrations in this well during multiple sampling events.

Arsenic groundwater data for Zone 7 wells are summarized in Table 10-1. In Zone 7, two groundwater sampling events were performed [1993 Site Inspection (AESSI95) and 1997 Lower Subase RI] and the total arsenic concentrations reported in 2 of the 7 wells closest to the Thames River (20MW7 and MW4-7RI) were greater than the Alternative SWPC during one of the events. In addition, the dissolved concentration of arsenic reported in one of these two wells (20MW7) during the same event also was greater than the Alternative SWPC. These elevated arsenic concentrations (18.8 µg/L total and 20 µg/L dissolved in 20MW7 and 11.0 µg/L total in MW4-7RI) were reported during the 1997 Lower Subase RI. The dissolved concentration reported in well MW4-7RI was less than the Alternative SWPC at 8.9 µg/L which indicates that there is no significant arsenic mobility concern for that well. Arsenic was not reported in the one previous sampling event at concentrations greater than the Alternative SWPC.

As shown on Table 10-2, the elevated arsenic concentrations reported in wells 20MW7 and MW4-7RI are not likely due to matrix interferences. However, as shown on Table 10-1, although wells 20MW7 and MW4-7RI are closest to the Thames River in their area of Zone 7, these two wells are far enough from the river (70 and 90 feet, respectively) that they are most probably not fully representative of conditions at the actual point of groundwater discharge to surface water.

10.1.3 Thames River

The western boundary of NSB-NLON is the Thames River. The lower portion of the Thames River is highly industrialized with numerous water-dependent industries (pharmaceutical, oil, chemical, and manufacturing), power plants, and waste treatment plants located along its banks. Non-point discharges from road, agricultural, and other runoff sources occur throughout the river's drainage basin. The Thames River and its tributaries drain approximately 1,471 square miles of eastern Connecticut, western Rhode Island, and south-central Massachusetts. The Thames River is a salt wedge estuary that is highly stratified, with fresher water on the surface and denser saline water beneath. The average freshwater flow discharging to Long Island Sound from the Thames River has been estimated at 222 million cubic feet per day (Soderberg and Bruno, 1971); however, freshwater flow in the Thames River is small in comparison to intertidal volume and exchange (Bohlen and Tramontano, 1977). The 7-day, 10-year low-flow rate for the freshwater portion of the Thames River at NSB-NLON is estimated to be 146.3 cubic feet per second. A dredged navigational channel runs north to south in the Thames River. At NSB-NLON, the dredged channel depth is approximately 40 feet below mean sea level (msl); depths outside the channel are shallow (2 to 10 feet), and the width of the river varies from approximately 600 to 900 feet.

Tidal changes of over 2 feet occur in the Thames River and influence the discharge of groundwater from the Lower Subase at NSB-NLON on a daily basis. The reversal in hydraulic gradient resulting from tidal influences generally occurs within 300 feet of the river.

CTDEP has classified Thames River water quality as SC/SB, which designates the water for marine fish, shellfish, and wildlife habitat, certain aquaculture operations, recreational uses, and industrial and other legitimate use, but the waters presently are not meeting water quality criteria or are not supporting one or more designated uses as a result of point or non-point sources of pollution (CTDEP Water Quality Standards, 2002). Sources contributing to this impairment include marinas, waterfowl, urban runoff/storm sewers, industrial and municipal point source discharges, and sanitary sewer overflows. CTDEP is currently revising the surface water quality standards and waters presently classified as SC/SB will no longer be classified as SB. This change will have no effect on CTDEP's approach to NSB-NLON because the goal for waters currently classified as SC/SB is to restore them to class SB.

The Thames River adjacent to NSB-NLON was investigated during several phases, and a Watershed Contaminated Source Document (WCSD) was prepared by the Navy in 2007 for the Lower Portion of the

Thames River. The results of these investigations showed that Navy sources contributed to contamination found in Thames River sediment in proximity to NSB-NLON. Thames River surface water results did not show any significant impacts. Arsenic and copper were not detected and lead was reported at a maximum total concentration of 1.5 µg/L.

10.2 CONCEPTUAL SITE MODEL

Sources of groundwater contamination and release mechanisms were described in Sections 10.1.2 for four zones 1, 4, 5, and 7. Historically, soil to groundwater transport was the primary transport mechanism for contamination to enter the groundwater in these four zones. Once in the groundwater, contamination will migrate with the groundwater and discharge to the surface water of the adjacent Thames River. A description of the Thames River was provided in Section 10.1.3. Fate and transport mechanisms will control the migration rates of contamination from the soil to groundwater and eventually to the Thames River.

CTDEP has classified groundwater beneath the Lower Subase as GB, indicating that the area has been used for long-term intense industrial or commercial development, a public water supply service is available, and the groundwater may not be suitable for human consumption without treatment. For the contaminants of concern (metals), CTDEP RSRs identify surface water protection criteria (SWPC) as the applicable criteria for GB-classified groundwater. The RSRs do not include numerical criteria to address the human health risk posed by direct contact with groundwater contaminants. However, the RSRs require that where groundwater contaminants pose a direct contact risk to human health, additional action must be taken to address that risk. Volatilization Criteria are not applicable for metals because they do not volatilize from groundwater. The direct exposure criteria consider dermal contact as the primary exposure pathway and the SWPC are *ground water criteria* based on protection of human and ecological receptors from exposure through ingestion of water and organisms. Because of its classification, the major objectives for evaluation of the groundwater are to prevent exposure of current and future construction workers to groundwater containing concentrations of contaminants (e.g., select metals) greater than the applicable direct exposure criteria for groundwater and minimize migration of groundwater contaminants that could cause adverse effects to downgradient receptors (e.g., ecological receptors in the adjacent Thames River). The Navy intends to manage any direct exposure risks to groundwater by managing contact with groundwater through land use controls and requiring the use of personal protective equipment if there is to be any contact with groundwater. Collection of additional groundwater data is not required to evaluate direct contact concerns.

The CTDEP provides surface water protection criteria (SWPC) and methods for developing alternative SWPC that can be used to determine whether contaminants in groundwater pose a potential threat to surface water. The SWPC and Alternative SWPC for arsenic, copper, and lead were discussed in Section 10.1.2. Significant sources of lead contamination were identified in the soil, suggesting the potential for lead contamination to migrate to groundwater. Some elevated total lead concentrations were

reported in the groundwater of some of the zones, suggesting that lead mobility from soil to groundwater may be a concern.

Table 10-1 summarizes the wells that had elevated concentrations of arsenic, copper, or lead or elevated detection limits. As discussed in Section 10.1.2, arsenic in groundwater is a concern in all four zones, and copper and lead are primarily a concern in the groundwater of Zone 1. Figure 10-8 shows a graphical depiction of the Conceptual Site Model.

SAP Worksheet #11 -- Project Quality Objectives/Systematic Planning Process Statements
(UFP-QAPP Manual Section 2.6.1)

11.1 PROBLEM DEFINITION

Multiple rounds of groundwater sampling were conducted in monitoring wells in Lower Subase Zones 1, 4, 5, and 7 during previous investigations; however, inconsistent detections and elevated detection limits for arsenic, copper, and lead in the historical data indicated that matrix interferences may have affected the laboratory's ability to measure those metals at concentrations low enough to support decision making. Past sampling techniques and high salinity are believed to have contributed to the artificially elevated metals concentrations and detection limits in historic data. The resultant uncertainties concerning actual metal concentrations in the range near applicable criteria and limited acceptance by CTDEP of the conclusions of the historical investigations, leave data gaps for arsenic, copper, and lead that must be filled. Efforts need to be taken during future sampling events, both in the field and by the laboratory, to avoid these potential interferences. The new data will also help to verify the extent of the groundwater contamination in the four zones.

Lead was also reported at elevated levels in soil and poses a potential migration concern. Investigation of lead concentrations in groundwater must also be undertaken to completely fill data gaps associated with soil to groundwater migration of lead and to complete the conceptual model for Zones 1, 4, 5, and 7. Additional soil sampling will be conducted under a separate UFP-SAP to directly address lead mobility in soil.

A Feasibility Study is currently being prepared for the groundwater in the Lower Subase. Until demonstrated otherwise, preparation of the Lower Subase Feasibility Study will continue under the assumption that treatment alternatives need to be considered for arsenic, copper, and lead in groundwater. Results from the first round of additional groundwater sampling will be used to provide preliminary judgment regarding this assumption.

11.2 INFORMATION INPUTS

- Data: Total and dissolved arsenic, copper, and lead concentrations in groundwater at Zones 1, 4, 5, and 7. Analytical methods must be sensitive enough to detect concentrations as low as applicable criteria and must have sensitivity sufficient to meet project objectives. See Worksheet #19 for identification of the selected methods and laboratory SOPs. Analytical methods (SW-846 1640 for sample preparation and elimination of matrix interferences and SW-846 6020B for analysis) were reviewed against the "State of Connecticut Department of Environmental Protection, Recommended Reasonable Confidence Protocol Quality Assurance and Quality Control Requirements Determination of Trace Metals by SW-846, Method 6020, Inductively Coupled Plasma Mass-Spectrometry, Version 2.0, July 2006" and were found to be consistent with the State of Connecticut method. Therefore, use of Methods 1640 and 6020B are suitable for this project for metals analyses of groundwater.

- Criteria: Evaluations of available groundwater data completed during the Lower Subase Feasibility Study reported arsenic, copper, and/or lead at concentrations greater than applicable CTDEP SWPC or Alternative SWPC in groundwater at Zones 1, 4, 5, and 7. As discussed in Section 10.1.2, the arsenic, copper, and lead criteria applicable to groundwater at Zone 1 are 10 µg/L (Alternative SWPC), 48 µg/L (SWPC), and 810 µg/L (Alternative SWPC), respectively. The arsenic, copper, and lead criteria applicable to groundwater at Zones 4, 5, and 7 are 10 µg/L (Alternative SWPC), 310 µg/L (Alternative SWPC), and 810 µg/L (Alternative SWPC), respectively. The standard lead SWPC (13 µg/L) was also retained for consideration to ensure appropriate detection limits are selected for the project.

- Groundwater Sampling Technique: Low flow sample collection methods/techniques that will avoid entrainment of suspended solids in groundwater samples. The TtNUS and EPA SOPs for this method are identified in Worksheet #21. Filtered groundwater samples (0.45 µm pore size) must also be collected to aid in interpreting the source and nature of contamination.

- Field Procedures: The location coordinates of the newly installed wells will be determined in the field by a professional surveyor licensed in the State of Connecticut. The lateral coordinates will be determined in the 1983 Connecticut State Plane coordinate system to an accuracy of 0.1 foot. The vertical elevations of the groundwater surface and top of well casing will be determined in the 1988 North American Vertical Datum to an accuracy of 0.01 foot. Groundwater level measurements will be taken to the nearest 0.01 foot. See WS #21 for the TtNUS SOPs governing these operations.

- Quality Control: QC samples include field duplicates and matrix spikes collected at the frequencies presented in Worksheet #20. Acceptance limits are presented in WS #28. The new groundwater data will be used for human health risk assessment; therefore, full validation will be performed and the logic for data qualification detailed in Region 1 EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses will be used to apply qualifiers to data. Because the four zones are near each other, the groundwater matrix is similar across all four zones and only one matrix spike per analytical batch (rather than per each zone) is required.

11.3 STUDY BOUNDARIES

The four zones to be investigated are located along the western portion of NSB-NLON and are bounded on the western side by the Thames River, although it is understood that groundwater potentially contaminated from activities in these zones is not contained by these boundaries. The zones are physically separated from each other. The physical boundaries that define the lateral extent of the four zones are illustrated on Figures 11-1 through 11-4. All wells where elevated metals concentrations have been observed are shallow (15 feet bgs or less). Therefore, the vertical extent of this study will be for

groundwater less than 15 feet bgs. All wells will have 10-foot screens, except one well (MW1-5PDI) which will have a 5-foot screen, due to the presence of bedrock at this location.

Groundwater levels fluctuate throughout the year based on precipitation events and changes in groundwater levels can impact groundwater flow directions. In addition, the groundwater at the Lower Subase is influenced on a daily basis by the tides. To capture the temporal impact, groundwater samples will be collected during two periods of the year (drier period in the Fall and wetter period in the Spring). To address tidal fluctuations and minimize potential salinity issues with the groundwater samples, sample collection will target low tide.

11.4 ANALYTIC APPROACH

The decision rule below defines how the data will be used.

If total arsenic, copper, and lead concentrations in all wells sampled within a zone are less than the applicable CTDEP SWPC/Alternative SWPC for the two rounds of sampling in the initial set of shallow wells for that zone, then recommend no further action. If total arsenic, copper, or lead concentrations in any sample obtained in the scheduled two rounds of sampling exceed the applicable CTDEP SWPC/Alternative SWPC, the Project Team will develop a plan for determining the boundaries of the arsenic, copper, or lead contamination in the groundwater and recommend that additional alternatives, consistent with the observed contamination, be considered for the groundwater. Filtered groundwater samples (0.45 µm pore size) will also be collected in the field to evaluate total suspended solids impact on metals concentrations. The dissolved metals concentration data will be useful for evaluating contaminant transport and treatability issues. Factors to be considered for this plan are:

- Locations of criteria exceedances
- Magnitude of criteria exceedances
- Available funding and schedule constraints

If lead is not detected in groundwater of any zone at a concentration greater than 13 µg/L during the two rounds of sampling, then no further investigation of groundwater to address lead mobility is required. Otherwise, the Project Team will plan an additional soil investigation that is designed to fully characterize the soil to groundwater mobility concern. In addition, the project team will determine the appropriate remedial alternatives that are required to address the soil to groundwater mobility concern.

As discussed in Section 10.1.2, the arsenic, copper, and lead criteria applicable to groundwater at Zone 1 are 10 µg/L (Alternative SWPC), 48 µg/L (SWPC), and 810 µg/L (Alternative SWPC), respectively. The arsenic, copper, and lead criteria applicable to groundwater at Zones 4, 5, and 7 are 10 µg/L (Alternative SWPC), 310 µg/L (Alternative SWPC), and 810 µg/L (Alternative SWPC), respectively. The standard

lead SWPC (13 µg/L) was also retained for consideration to ensure appropriate detection limits are selected for the project.

11.5 PERFORMANCE OR ACCEPTANCE CRITERIA

The project team allocated a relatively small number of samples based on groundwater flow paths and as efficiently as possible with the resources available. The samples were allocated using a judgmental sampling design based on knowledge of past spatial coverage by samples and knowledge of site operations. The intent is to efficiently identify groundwater contamination, if any, in Zones 1, 4, 5, and 7 along the western portion of the base while achieving spatial coverage and analytical sensitivity sufficient to fill data gaps. Because the sampling design is judgmental, no statistical computation of the required number of samples and no specification of statistically-based decision performance objectives were necessary. Direct comparison of measured concentrations to the project criteria (CTDEP SWPC/Alternative SWPC) will be used to determine whether criteria are exceeded.

11.6 PLAN DEVELOPMENT FOR OBTAINING DATA

To complete the characterization of groundwater at the four zones, groundwater samples will be collected from 15 wells during two rounds of sampling. Four of the 15 wells are replacement wells and will be installed and developed prior to sampling. Wells MW1-1PDI, MW1-4PDI, MW1-5PDI, and MW1-7PDI will replace wells 13MW7, 13MW15, 19MW4, and 20MW7, respectively, which were previously destroyed or not located. The remaining 13 wells will be developed prior to sampling. Worksheet #17 provides a detailed discussion on the design and rationale of the field sampling plan. The samples will be analyzed for total and dissolved arsenic, copper, and lead. Figures 11-1 through 11-4 show the proposed sample locations.

SAP Worksheet #12 -- Measurement Performance Criteria Table
(UFP-QAPP Manual Section 2.6.2)

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
Field Duplicate	All Fractions	One per 10 field samples collected	Precision	Aqueous samples Relative percent difference (RPD) of 30	S

Source water blanks will not be collected because dedicated tubing will be used to collected samples from each well. Because the tubing will not be reused, no decontamination will be required between wells.

SAP Worksheet #13 -- Secondary Data Criteria and Limitations Table
(UFP-QAPP Manual Section 2.7)

Secondary Data	**Data Source** (originating organization, report title and date)	**Data Generator(s)** (originating organization, data types, data generation/ collection dates)	**How Data Will Be Used**	**Limitations on Data Use**
Lower Subase Remedial Investigation	Tetra Tech Lower Subase Remedial Investigation for NSB-NLON, Groton, Connecticut 1999	Tetra Tech Groundwater samples 1997	Data will be used with new data collected for this project to characterize presence and extent of groundwater contamination in Zones 1, 4, 5, and 7.	Available data are over 10 years old and may not represent current conditions. Analytical methods previously used may have been impacted by matrix interferences and resulted in elevated detection limits and potentially false positive detections. With these limitations in mind, the existing data will be cautiously used for comparison to newly collected data. The newly collected data will be given greater weight for making decisions.

SAP Worksheet #14 -- Summary of Project Tasks
(UFP-QAPP Manual Section 2.8.1)

The project tasks include the following:

- Mobilization/Demobilization
- Utility Clearance
- Monitoring Well Abandonment
- Monitoring Well Installation
- Surveying
- Monitoring Well Development
- Water-Level Measurements
- Groundwater Purging
- Groundwater Sampling
- QA/QC Tasks
- Sample Handling and Shipping
- Equipment Decontamination
- Investigation-Derived Waste Management
- Analytical Tasks
- Data Management
- Assessment and Oversight
- Data Review
- Project Report

The Standard Operating Procedures (SOPs) and field documents referenced below and in the various worksheets are included in Appendices A and B, respectively.

- **Mobilization/Demobilization** - A field team orientation meeting will be conducted prior to the start of fieldwork to familiarize the team personnel with the site's health and safety requirements, objectives and scope of the field activities, and chain of command. Because the field work will be broken into three separate events (well installation/development, Round 1 sampling, and Round 2 sampling) which will be conducted at different times, multiple team meetings will be required. The meetings will be attended by the FOL/SSO, PM, and project chemist. Mobilization activities will include transporting field personnel, equipment, monitoring well installation supplies, and the drilling subcontractor to the site. The first mobilization is planned for April 2010 and the subsequent mobilizations will occur as the schedule permits. A 1-hour health and safety meeting will be conducted prior to initiating onsite activities. All subcontractor personnel (including substitutes) will attend the applicable meeting. Tetra Tech will coordinate with the Navy Point of Contact (POC) at NSB-NLON (Environmental Restoration Program Manager) regarding acquisition of passes, security and access issues, and daily activities. Tetra Tech will also coordinate with the Navy RPM and stakeholders regarding the field activities. Demobilization will include transporting personnel, field equipment, supplies, and the drilling subcontractor from the site, performing general site cleanup, and organizing and finalizing field paperwork.

- **Utility Clearance -** Utility clearance will be conducted by a subcontractor in coordination with NSB-NLON. This SAP will provide the CTDEP with notification regarding the installation of the new

permanent wells, and the monitoring well boring logs and well installation diagrams will be submitted to the CTDEP in the data report that is generated from the work.

- **Monitoring Well Abandonment -** Two existing monitoring wells, 13MW7 and 19MW4, are damaged beyond repair and require abandonment. In the State of Connecticut, well abandonment must comply with the Connecticut Well Drilling Code, i.e., Title 25, Section 128 of Regulations of Connecticut State Agencies (Appendix F). Subsections of §25-128 that are relevant to abandonment include §25-128-36 Definitions; §25-128-56 Abandonment of wells, responsibility; §25-128-57 Procedure of abandonment; §25-128-58b Contractor-limited to well non water-supply drilling; §25-128-61 Permit requirement; and §25-128-62 Contents of permit application.

  The following abandonment procedures are specified by the State of Connecticut (Connecticut, 2005):

  - Abandonment procedures must be performed or directed by a Connecticut-registered well driller.

  - Prior to abandoning any wells, a registered well contractor must apply to the State Plumbing and Piping Work Examining Board for a permit, and submit the completed permit application to the Ledgelight Health District for approval.

  - Based on the regulations, each well should be chlorinated prior to abandonment using the chlorine solution specified in the regulations. However, this requirement is for drinking water wells and is not applicable to the wells at NSB-NLON.

  - Each well must be checked from land surface to the entire depth of the well before it is sealed, to insure against the presence of any obstructions that could interfere with sealing operations.

  - The well bore must be filled and sealed with grout, which must be placed in such a way to prevent voids or dilution. Acceptable grouts include neat cement grout, sand cement grout, bentonite clay grout, or sand clay or bentonite cement grout. Grout mixtures and proportions are specified under §25-128-36 Definitions.

  - Upon completion of abandonment, the top of the casing or grout may be terminated at least 4 feet below the ground surface.

However, because this work will be conducted under CERCLA, the Navy does not intend to formally apply for the well abandonment permits, but will meet the intent of the regulations during abandonment activities. This process has been used during previous well abandonment activities at NSB-NLON. All abandonment logs will subsequently be provided to the CTDEP as part of the Groundwater PDI Completion Report.

- **Monitoring Well Installation** - Two existing monitoring wells have been damaged beyond repair, and two additional monitoring wells were not located during the 2007 Monitoring Well Inventory. Because of regulatory concerns regarding past reported contaminant concentrations in the wells, they will be replaced as close as possible to their original location. The construction of the replacement monitoring wells will be the same as the damaged/missing wells so that new data obtained from the wells are comparable to previous data. Existing well construction details are provided in Table B-1 of Appendix B. The new well installed to replace 13MW7 will be named MW1-1PDI. It is anticipated that MW1-1PDI will be installed to 14 feet bgs and screened from 4 to 14 feet bgs (i.e., 10-foot screen). The new well installed to replace well 13MW15 will be MW1-4PDI. It is anticipated that MW1-4PDI will be installed to 13 feet bgs and screened from 3 to 13 feet bgs. The new well installed to replace well 19MW4 will be named MW1-5PDI. Well MW1-5PDI will be constructed similarly to well 19MW4 in that the screen will be placed to the top of bedrock to allow monitoring the shallow overburden materials directly above the bedrock surface. Well 19MW4 was only installed to 5.75 feet bgs due to refusal because of shallow bedrock at this depth. The new well installed to replace well 20MW7 will be named MW1-7PDI. It is anticipated that MW1-7PDI will be installed to 13 feet bgs and screened from 3 to 13 bgs. Boring Logs for monitoring wells 13MW7, 13MW15, 19MW4, and 20MW7 are provided in Appendix B-2.

  The monitoring wells are located in an area that may be tidally influenced, so consideration should be given to the predicted tide heights and tidal range (daily, average, and seasonal fluctuations) for the area during drilling and installation activities in order to gauge the productivity of the new wells. The well screens will be set so that groundwater samples can be collected at low tide. The screens should be set so that the average tidal elevation range is within the screened interval. The screen should be set so the high tide level does not rise above the top of the screened interval. Field personnel must be aware of current tidal conditions in order to estimate monitoring well productivity at low tide. Based on previous data for wells near the proposed replacement locations for MW1-1PDI, MW1-4PDI, MW1-5PDI, and MW1-7PDI, MW1-5PDI is not expected to be tidally influenced, and MW1-1PDI, MW1-4PDI, and MW1-7PDI are expected to be tidally influenced.

  Wells will be installed using a hollow-stem auger with a 4-4.25-inch, inner diameter (ID) and 8- to 9-inch outer diameter that will allow for a minimum 2-inch-thick sand pack in the annulus between all sides of each new well and the sidewalls of the borehole. Monitoring wells will be installed through the augers upon completion of the borings.

  Monitoring wells will be constructed of 2-inch inside diameter (ID), flush-threaded, polyvinyl chloride (PVC) well screen with a 0.010-inch slot size and compatibly threaded PVC well casing. A primary filter pack of clean silica sand will be installed flush with the bottom of the well to a minimum of 12 inches above the top of the well screen. A sand passing U.S. Standard Sieve No. 30-50 will be used for fine/silty sand formations (0.010-inch slot size). A minimum 12-inch thick seal of 100 percent

sodium bentonite pellets will be installed above the primary filter pack and allowed to hydrate in accordance with the manufacturer's recommendations. A concrete pad (minimum of 6 inch thickness and 3 feet by 3 feet square) will be installed above the bentonite seal and around the casing.

A boring log and well construction sheet will be produced for each new well. Cuttings will be containerized and managed as investigative-derived waste (IDW). Augers and other well construction equipment will be decontaminated. After completion of these flush mount wells, metal protective well casing will be installed. An 8- or 10-inch protective steel mount cover and casing equipped with a locking cap will be grouted in place around each well. The locks will be (1) keyed alike to the rest of the wells at NSB-NLON or (2) a key for the locks will be provided to NSB-NLON. The top of the riser pipe will be placed 4 to 5 inches bgs, and the annular space between the existing ground surface and the protective casing will be filled with concrete. Wells will be installed in accordance with SOP GH-2.8 in Appendix A and with applicable Connecticut regulations.

- **Surveying** - The four new wells will be surveyed by a professional surveyor licensed in the State of Connecticut to determine the horizontal location and ground surface and top of casing elevations. The lateral coordinates will be determined in the 1983 Connecticut State Plane coordinate system to an accuracy of 0.1 foot. The vertical elevations of the groundwater surface and top of well casing will be determined in the 1988 North American Vertical Datum to an accuracy of 0.01 foot.

- **Monitoring Well Development** - New and existing monitoring wells will be developed prior to groundwater sampling to remove fine material from the annular space around the sand pack and screened interval of the well. The method to be used to develop the wells will be determined by field personnel and will include either surging and bailing or pumping. The wells will be developed until a minimum of three standing well volumes in the well casing plus three times the water volume in the saturated sand pack are removed or until the discharge water is visibly clear and temperature, pH, and specific conductivity have stabilized with 10 percent variance for three consecutive measurements or as determined by FOL. Best efforts will be made to develop each well so that the groundwater turbidity is less than 10 nephelometric turbidity units (NTUs). All water quality measurements and volumes removed will be recorded for each well on a well development form. All development water will be containerized and managed as IDW. All monitoring well development will also be done in accordance with TtNUS SOP GH 2-8 in Appendix A.

- **Water-Level Measurements -** After the monitoring wells have been developed and allowed to recover, water-level measurements will be collected from the existing and new monitoring wells. All water-level measurements will be taken within a short time period (maximum of 2 hours) of consistent weather and tidal conditions to minimize atmospheric/precipitation effects on groundwater levels. Water-level measurements will be done in accordance with TtNUS SOP GH-1.2 in Appendix A.

- **Groundwater Purging -** All monitoring wells will be purged before sampling using a peristaltic pump and polyethylene tubing and following low-flow procedures provided by EPA SOP EQASOP-GW001 in Appendix A. The tubing intake will be set at the midpoint of the saturated screen interval. The water level and total depth of the monitoring well will be measured before the start of purging. Purging will begin approximately 2 hours before low-tide is predicted in the adjacent Thames River. Tidal predictions for Station 8461490 at New London, CT can be found on NOAA's website (http://co-ops.nos.noaa.gov). A time adjustment factor (approximately 10 minutes) will be added to the time predicted to account for the location difference between Station 8461490 and the Lower Subase. The purging will occur immediately before each well is sampled. Groundwater level measurements will be taken to the nearest 0.01 foot.

  Temperature, pH, turbidity, specific conductance, dissolved oxygen (DO), and salinity will be measured during purging. These measurements will be taken at the start of purging and every 5 to 10 minutes subsequently until the temperature, specific conductance, salinity, and water level (except in tidal wells) have stabilized within 10 percent over a minimum of three readings, and turbidity is less than 10 NTUs. If turbidity does not decrease to less than 10 NTUs after 2 hours, purging will be considered complete and collection will begin. Purge water removed from the wells will be containerized and handled/disposed as IDW. Groundwater purging will be conducted in accordance with TtNUS SOP SA-1.1 and EPA SOP EQASOP-GW001 in Appendix A.

- **Groundwater Sampling -** Groundwater samples will be collected from 15 wells as identified in WS#18. The table below summarizes the rationale for selection of the wells.

Zone	Well ID	Rationale for Selection
1	13MW19	Historic exceedances and close proximity to river.
1	13MW20	Historic exceedances.
1	13MW21	Historic exceedances and close proximity to river.
1	FOMW14	Historic exceedances.
1	MW1-1PDI (formerly 13MW7)	Close proximity to river.
4	13MW13	Historic exceedances.
4	13MW14	Close proximity to river.
4	MW1-4PDI (formerly 13MW15)	Historic exceedances and close proximity to river.
4	NESO10	Historic exceedances and close proximity to river.
4	NESO11	Historic exceedances.
5	19MW3	Close proximity to river.
5	MW1-5PDI (formerly 19MW4)	Historic exceedances.

Zone	Well ID	Rationale for Selection
7	MW1-7PDI (formerly 20MW7)	Historic exceedances and close proximity to river.
7	MW3-7RI	Close proximity to river.
7	MW4-7RI	Historic exceedances and close proximity to river.

Field personnel will take reasonable necessary precautions to minimize cross-contamination of samples from environmental sources during sampling. Methods discussed in EPA Method 1640 (April 1997) and EPA Method 1669 (July 1996) will be considered by the field personnel.

Samples will be collected and analyzed for both total and dissolved select metals. A 0.45-micron membrane filter will be used for the dissolved metals collection. A fresh filter will be used to collect each filtered sample. A minimum of two rounds of samples will be collected at two different times of the year (i.e. wet season / highest groundwater level and dry season / lowest groundwater level). All samples will be collected near low tide to minimize salinity and contaminant dilution impacts on the samples and therefore represent the most representative sampling. Depending on the results of purging, sampling will typically be conducted within a 2-hour window bracketing the time of the predicted low-tide (i.e., sampling can begin approximately 1 hour prior to and 1 hour after low tide). Information regarding determining low tides at New London are provided in the section on groundwater purging. Samples will be collected in accordance with TtNUS SOPs SA-1.1 and SA-6.1 in Appendix A.

Low-flow sampling techniques and appropriate analytical methods will be used during the additional sampling efforts to minimize matrix interferences and attain appropriate detection limits. In addition, two rounds of samples will be collected under two different hydrologic regimes and low tide because these conditions may impact the detection of the metals. The new data will reduce the uncertainty associated with the historical data set and confirm the presence of select metals in Zones 1, 4, 5, and 7 of the Lower Subase.

- **QA/QC Tasks** - Field QA/QC samples will be collected as part of the investigation including field duplicates. Worksheet #20 presents the field QA/QC sample summary. Also, additional sample volume will be collected as necessary for laboratory QC analysis of matrix spike and laboratory duplicate analysis.

- **Sample Handling and Shipping** - Sample handling and shipping procedures presented in Tetra Tech SOP SA-6.1 (Appendix A) will be followed. Sample log sheets will be prepared for each sample collected and will include sample-specific information, as well as information that documents sampling activities. Sample log sheets will be signed and dated, and the appropriate chain of custody procedures will be followed until the samples reach the analytical laboratory.

- **Equipment Decontamination** - The decontamination procedures presented in Tetra Tech SOP SA-7.1 in Appendix A will be followed for this project. To minimize decontamination, wells will be sampled using dedicated tubing which will not require decontamination. Therefore, decontamination of this equipment will not be necessary. Personal protective equipment and emergency decontamination procedures are discussed in the HASP. However, when reinstalling the monitoring wells the equipment will be decontaminated prior to beginning work and between locations.

- **Investigation-Derived Waste Management** – IDW generated during drilling, purging, development, sampling, and decontamination activities will be containerized in Department of Transportation (DOT)-approved 55-gallon drums. IDW will be stored in a centralized location designated by the base. Drums will be separated by aqueous and soil cuttings. These drums will be sampled and shipped by the IDW subcontractor. Used personal protective equipment and general project refuse will be collected and placed in plastic bags (doubly lined) and disposed in a Navy-approved trash receptacle.

- **Analytical Tasks** – Chemical analysis of the groundwater samples for select metals will be performed by Columbia Analytical Services, Inc. (CAS), the subcontracted laboratory. Analyses will be performed in accordance with the analytical methods identified in Worksheet #18 and the requirements of the technical specification for laboratory services developed by Tetra Tech for this work. The technical specification is included as Appendix C. The subcontracted laboratory will meet the QLs and Method Detection Limits (MDLs) specified in Worksheet #15.

  The technical specification details the analytical requirements, number of samples, matrix, analytical methods to be performed, preservatives, holding times, QLs required for the project, and data deliverables. CAS will perform the chemical analyses following laboratory-specific SOPs developed based on the methods listed in Worksheet #23. Copies of the laboratory SOPs are included in Appendix D .

- **Data Management** - Project data will be managed according to the procedures outlined on the following worksheets:

  - Project documentation and records
    - -- Field sample collection and field measurement records - See Worksheets #27 and #29
    - -- Laboratory data package deliverables - See Worksheet #30
    - -- Data assessment documents and records - See Worksheet #29

  - Data recording formats - See Worksheet #27

  - Data handling, management, tracking, and control

Data Handling and Management - After the field investigation is completed, field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity. The data handling procedures to be followed by the laboratory will meet the requirements of the technical specification (see Appendix C). The electronic data results will be automatically downloaded into the Tetra Tech database in accordance with proprietary Tetra Tech processes. The data will be subsequently loaded by Tetra Tech to the Navy's data management system (NIRIS).

Data Tracking and Control - The Tetra Tech PM (or designee) is responsible for the overall tracking and control of data generated for the project.

Data Tracking - Data are tracked from generation to archiving in the Tetra Tech project-specific files. The Project Chemist (or designee) is responsible for tracking the samples collected and shipped to the contract laboratory. Upon receipt of the data packages from the analytical laboratory, the Project Chemist will oversee the data validation effort, which includes verifying that the data packages are complete and results for all samples have been delivered by the analytical laboratory.

Data Storage, Archiving, and Retrieval - The data packages received from the subcontract laboratory are tracked in the data validation logbook. After the data are validated, the data packages are entered into the Tetra Tech CLEAN file system and archived in secure files. All data uploaded to the Navy's data management system (NIRIS) will be accessible electronically to all parties with access to the system. The field records including field logbooks, sample log sheets, and chain-of-custody records will be submitted by the FOL to be entered into the CLEAN file system prior to archiving in secure project files. The project files are audited for accuracy and completeness. At the completion of the Navy contract, the records will be stored by Tetra Tech.

Data Security. The Tetra Tech project files are restricted to designated personnel only. Records may only be borrowed temporarily from the project file using a sign-out system. The Tetra Tech Data Manager maintains the electronic data files. Access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

- **Assessment and Oversight** - See Worksheet #32 for assessment findings and corrective actions and Worksheet #33 for QA management reports.

- **Data Review -** Data reviews shall be conducted in accordance with the procedures outlined on the following worksheets:

- Data verification – See Worksheet #34
- Data validation – See Worksheets #35 and #36
- Usability assessment – See Worksheet #37

- **Project Report** - The analytical data generated under this SAP will be used for the following purposes:

  - To determine if treatment alternatives for arsenic and copper in groundwater are necessary.

Draft versions of these documents will be prepared and submitted in hardcopy format to the Navy, EPA, CTDEP, and NOAA for review and comment. Tetra Tech will develop responses to comments received on the draft reports. The final versions of the reports will submitted in hardcopy and electronic format to the project team.

SAP Worksheet #15 -- Reference Limits and Evaluation Table

(UFP-QAPP Manual Section 2.8.1)

Matrix: Aqueous
Analytical Group: Metals

Analyte	CAS Number	Project Action Limit (µg/L)		Project Action Limit Reference[1]	Project Quantitation Limit Goal (µg/L)	Laboratory[2]	
		Zone 1	Zones 4, 5, and 7			QL (µg/L)	MDL (µg/L)
Arsenic	7440-38-2	10	10	Alt. CTDEP SWPC	3.33	0.5	0.08
Copper	7440-50-8	48	310	CTDEP SWPC and Alt. SWPC	16	0.1	0.02
Lead	7439-92-1	810	810	Alt. CTDEP SWPC	13[3]	0.02	0.009

1 CTDEP SWPC: Connecticut Department of Environmental Protection, Remediation Standard Regulations, Surface Water Protection Criteria, 1996 Alt. CTDEP SWPC: Alternative CTDEP SWPC (Approval letter, see Appendix E)
2 Columbia Analytical Services-specific MDLs and QLs are presented.
3 The standard SWPC was selected to avoid losing detections between 13 µg/L and 810 µg/L.

SAP Worksheet #16 -- Project Schedule/Timeline Table (optional format)
(UFP-QAPP Manual Section 2.8.2)

Activity	Organization	Dates (MM/DD/YY)		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Internal Draft UFP-SAP	Tetra Tech	10/16/09	12/18/09	Internal Draft UFP-SAP	12/18/09
Navy Review	Navy	12/18/09	1/5/10	NA	NA
Resolve Comments	Tetra Tech	12/29/09	1/8/10	NA	NA
Draft UFP-SAP	Tetra Tech	1/8/10	1/21/10	Draft UFP-SAP	1/21/10
Regulator Review	EPA and CTDEP	1/22/10	3/2/10	NA	NA
Comment Resolution	Tetra Tech	2/23/10	3/24/10	Responses to Comments	3/24/10
Final UFP-SAP	Tetra Tech	3/23/10	4/9/10	Final UFP-SAP	4/9/10
Round 1 Field Work and Analysis	Tetra Tech	4/14/10	5/31/10	NA	NA
Round 1 Data Validation	Tetra Tech	6/1/10	6/30/10	Final Analytical Data Tables	6/30/10
Round 1 Technical Memorandum	Tetra Tech	7/1/10	10/27/10	Technical Memorandum	10/27/10
Round 2 Field Work and Analysis	Tetra Tech	9/1/10	10/15/10	NA	NA
Round 2 Data Validation	Tetra Tech	10/18/10	11/16/10	Final Analytical Data Tables	11/16/10
Technical Memorandum	Tetra Tech	11/17/10	3/21/11	Completion Report	3/21/11

SAP Worksheet #17 -- Sampling Design and Rationale
(UFP-QAPP Manual Section 3.1.1)

A limited number of monitoring well locations were selected to determine if metals concentrations greater than criteria are present in onsite groundwater. These wells are biased toward locations that historically demonstrated reportedly elevated concentrations of arsenic, copper, and lead in Zones 1, 4, 5, and 7 and wells downgradient of those areas that are located closer to the Thames River. Monitoring wells were sampled more than a decade ago and concern has been expressed that the observed metals concentrations were affected by sampling techniques that were prone to entraining suspended solids (turbidity) or analytical methods that are affected by salinity. To obtain a better understanding of metal concentrations at significantly different times of year, two rounds of groundwater samples will be collected under two different hydrologic regimes (i.e. wet season / highest groundwater level and dry season / lowest groundwater level). The samples will be collected at low tide to minimize salinity and dilution of metal contaminants in the samples.

Data collection during previous studies indicated that groundwater contained elevated levels of arsenic, copper, and lead. Soil investigations also demonstrated the presence of lead contamination in soil which may have the potential to migrate to groundwater.

If contamination is shown to exist in the selected wells and it is unbounded by samples from wells that have concentrations less than the applicable criteria, additional wells will need to be added to the monitoring well network in the future to fully delineate the extent of contamination (see Section 11.4).

SAP Worksheet #18 -- Sampling Locations and Methods/SOP Requirements Table
(UFP-QAPP Manual Section 3.1.1)

Sampling Location / ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference[1]
Zone 1				
13MW19	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
13MW20	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
13MW21	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
FOMW14	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
MW1-1PDI (formerly 13MW7)	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
Zone 4				
13MW13	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
13MW14	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
MW1-4PDI (formerly 13MW15)	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
NESO10	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3

Sampling Location / ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference[1]
NESO11	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
Zone 5				
19MW3	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
MW1-5PDI (formerly 19MW4)	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
Zone 7				
MW1-7RI (formerly 20MW7)	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
MW3-7RI	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3
MW4-7RI	Aqueous	Dissolved and Total: Arsenic, Copper, and Lead	1	CT-04, GH2-1, CT-05, SA-1.1, SA-6.3

1 SOP that describes the sample collection procedures. SOPs are provided in Appendix A.

SAP Worksheet #19 -- Analytical SOP Requirements Table
(UFP-QAPP Manual Section 3.1.1)

Matrix	**Analytical Group**	**Analytical and Preparation Method/ SOP Reference[1]**	**Container** (number, size, and type)	**Sample volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time[2]** (preparation / analysis)
Aqueous	Arsenic, Copper, and Lead	1640 (preparation)/MET-RPMS: Lab SOP 2 6020 (analytical)/MET-6020: Lab SOP 1	One 1000 mL plastic jar**	1000 mL	Nitric acid to a pH < 2	6 months to analysis

1 See the Analytical SOP References Table (Worksheet #23).
2 Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

** If QC is required, three 1000 mL bottles

SAP Worksheet #20 -- Field Quality Control Sample Summary Table
(UFP-QAPP Manual Section 3.1.1)

No trip blanks will be required for this investigation because no samples are being collected for VOC analysis.

Field duplicate samples will be collected at a frequency of 1 per 10 samples.

Precision and accuracy will be determined using laboratory duplicates, and laboratory control spikes (LCS), and matrix spikes as per Worksheet #28.

Matrix	Analytical Group	No. of Sampling Locations[1] Per Round	No. of Field Duplicates[2] Per Round	No. of MS Samples Per Round	No. of Field Blanks Per Round	No. of Equip. Blanks Per Round	No. of VOA Trip Blanks Per Round	No. of PT Samples[3] Per Round	Total No. of Samples to Lab Per Round
Groundwater	Arsenic – Total	15[4]	2	1	0	0	0	0	18
Groundwater	Arsenic – Dissolved	15[4]	2	1	0	0	0	0	18
Groundwater	Copper – Total	15[4]	2	1	0	0	0	0	18
Groundwater	Copper – Dissolved	15[4]	2	1	0	0	0	0	18
Groundwater	Lead – Total	15[4]	2	1	0	0	0	0	18
Groundwater	Lead - Dissolved	15[4]	2	1	0	0	0	0	18

1 Samples will be collected from the 15 wells identified in Zones 1, 4, 5, and 7.
2 Collect 1 field duplicate per 10 field samples.
3 The number of batch or project-specific proficiency testing (PT) samples are optional but highly recommended.
4 Refer to Worksheet #18 for analyses per sample location.

SAP Worksheet #21 -- Project Sampling SOP References Table
(UFP-QAPP Manual Section 3.1.2)

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
CT-04	Sample Nomenclature, 3/9/09	Tetra Tech	NA	Y	
CT-05	Database Records and Quality Assurance, 1/29/01	Tetra Tech	NA	Y	
GH-1.2	Evaluation of Existing Monitoring Wells and Water Level Measurement, 9/03	Tetra Tech	Water Level Measuring Device	Y	
GH-2.8	Groundwater Monitoring Well Installation, 9/03	Tetra Tech	Drilling Equipment (Drill Rigs and Hollow-Stem Augers) and Well Development Equipment (Pumps)	Y	
SA-1.1	Groundwater Sample Acquisition and Onsite Water Quality Testing, 4/7/08	Tetra Tech	Water Quality Meter and Low-Flow Sampling Equipment	Y	
SA-6.1	Non-Radiological Sample Handling, 2/04	Tetra Tech	Sample Bottleware, Packaging Material, Shipping Materials	Y	
SA-6.3	Field Documentation, 3/9/09	Tetra Tech	Field Logbook, Field Sample Forms, Boring Logs	Y	
SA-7.1	Decontamination of Field Equipment, 1/28/09	Tetra Tech	Decontaminate hollow-stem auger and cutting head (scrub brushes, phosphate-free detergent, potable water rinse)	Y	
EQASOP-GW001	Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells; Revision 3, January 16, 2010	EPA Region 1	Submersible pump, multiparameter meter, turbidimeter	N	SOP is included in Appendix A.

Reference Number	Title, Revision Date and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
EQASOP-Field Calibrat	Calibration of Field Instruments; Revision 2, January 19, 2010	EPA Region 1	Field instruments used to measure water quality parameters for groundwater	N	SOP is included in Appendix A

SAP Worksheet #22 -- Field Equipment Calibration, Maintenance, Testing, and Inspection Table
(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity[1]	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
YSI 600 Series Water Quality Meter	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance	Operator correction or Replacement	FOL	EQASOP-GW001 EQPSOP-Field Calibrat	Rental field equipment will be used
Turbidity Meter	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance	Operator correction or Replacement	FOL	EQASOP-GW001 EQPSOP-Field Calibrat	
Water Level Indicator	Visual Inspection Field checks as per manufacturer	Daily Once upon receiving from vendor	0.01 foot accuracy	Operator correction or Replacement	FOL	GH-1.2	
Photo-Ionization Detector (PID)	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance	Operator correction or Replacement	FOL	Operation according to manufacturer's instructions	
Peristaltic Pump	Visual Inspection	Daily	Equipment Inspection Sheet Criteria	Replace	FOL	SA-1.1, Sec. 6.9.2.2	

1 Rental equipment and instruments will be used in the field. The rental firms will be responsible for the proper care, maintenance, and repair of these items, and for tracking and documenting equipment and instrument maintenance and repairs.

SAP Worksheet #23 -- Analytical SOP References Table
(UFP-QAPP Manual Section 3.2.1)

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
MET-6020	Determination of Metals and Trace Elements by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS); EPA Method 6020; Rev 12; 09/26/2008	Definitive	Water, Metals	ICP-MS	CAS	N
MET-RPMS	Trace Metals in Water by Pre-concentration using Reductive Precipitation Followed by ICP-MS analysis; Rev 5; 2/14/2008	Definitive	Water, Metals	preparation	CAS	Y(1)
SMO-GEN	Sample Receiving; Rev 25; 4/9/2009	Definitive	Water	sample receipt	CAS	N
SMO-SCOC	Sample Tracking and Internal Chain-of-Custody; Rev 12; 4/24/2009	Definitive	Water	chain of custody	CAS	N
SMO-SDIS	Sample Disposal; Rev 7; 3/26/2008	Definitive	Water	sample disposal	CAS	N

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
ADM-ARCH	Data Archiving; Rev 4; 8/7/2008	Definitive	Water	data archiving	CAS	N
ADM-RG	Data Reporting and Report Generation; Rev 6; 8/07/2008	Definitive	Water	data reporting	CAS	N

1 After preconcentration sample volume will be increased to yield an effective concentration factor of 1X. Method is being used to eliminate matrix interferences and not for sample concentration.

SAP Worksheet #24 -- Analytical Instrument Calibration Table
(UFP-QAPP Manual Section 3.2.2)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
ICP-MS	Initial Calibration	The instrument is calibrated at the beginning of each day or if the QC is out of criteria.	The instrument is calibrated by a one point calibration per manufacturer's guidelines. Recovery within 90-110% of the true values.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Chemist/Analyst	1
	ICV - Second Source	Following initial calibration, prior to the analysis of samples.	The %R must be within 90-110% of the true value.	Investigate reasons for failure, reanalyze once. If still unacceptable, repeat calibration.	Analyst, Department Manager	
	Initial Calibration Blank (ICB)	After every initial calibration.	No analytes detected > QL.	Correct the problem, then re-prepare and reanalyze.	Chemist/Analyst	
	Continuing Calibration (CCV)	Analyze a standard after every 10 samples and at the end of the sequence.	90-110% recovery of true value.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Chemist/Analyst	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference[1]
	Continuing Calibration Blank (CCB)	After every continuing calibration verification.	No analytes detected > QL.	Correct the problem, then re-prepare and reanalyze calibration blank and previous 10 samples.	Chemist/Analyst	
	Low-Level Check Standard	Daily after ICAL and before samples.	The %R must be within 80-120% of the true value.	Investigate and perform necessary equipment maintenance. Recalibrate and reanalyze all affected samples.	Analyst, Department Manager	

1 See Analytical SOP References table (Worksheet #23).

SAP Worksheet #25 -- Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table
(UFP-QAPP Manual Section 3.2.3)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[1]
ICP – MS	Perform leak test, change pump tubing, clean torch and sampler cones.	Monitor instrument performance via CCV.	Monitor instrument performance via CCV and CCB.	Daily	All analytes within +/- 10%	Replace pump tubing, clean torch and cones	Chemist/Analyst	1
		Monitor instrument performance via CCB.			no analytes > QL.		Chemist/Analyst	

1 See the Analytical SOP References table (Worksheet #23).

SAP Worksheet #26 -- Sample Handling System
(UFP-QAPP Manual Appendix A)

SAMPLE HANDLING SYSTEM

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FOL (TBD)/Tetra Tech
Sample Packaging (Personnel/Organization): FOL (TBD)/Tetra Tech
Coordination of Shipment (Personnel/Organization): FOL (TBD)/Tetra Tech
Type of Shipment/Carrier: Tetra Tech to provide (UPS or FED EX)
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodians/ Columbia Analytical Services
Sample Custody and Storage (Personnel/Organization): Sample Custodians/ Columbia Analytical Services
Sample Preparation (Personnel/Organization): Metals Digestion Department / Columbia Analytical Services
Sample Determinative Analysis (Personnel/Organization): Metals Analysis Department / Columbia Analytical Services
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 60 days from receipt
Sample Extract/Digestate Storage (No. of days from extraction/digestion) : 3 months from sample digestion/extraction
Biological Sample Storage (No. of days from sample collection): N/A
SAMPLE DISPOSAL
Personnel/Organization: Waste Disposal Technician/ Columbia Analytical Services
Number of Days from Analysis: 30 days from submittal of final report or 60 days from receipt, whichever is longer

SAP Worksheet #27 – Sample Custody Requirements Table
(UFP-QAPP Manual Section 3.3.3)

Sample Designation and Tracking System

Each sample collected will be assigned a unique sample tracking number used to catalog the associated results. The sample tracking number will consist of alpha-numeric characters identifying the site, sample medium, location, core, and depth. Any other pertinent information regarding sample identification will be recorded on the sample log sheets or in the field logbooks. The alpha-numeric (A-N) coding to be used in the sample system is described below.

AAN	-	AA	-	NNAANN	-	(NN)	- (NN)
(Site ID)	-	(Medium)	-	(Well)	-	(Year)	- (Round)

Site identifier: LS1 for Zone 1

Medium identifier: "GW" for groundwater samples

Well location identifier: Each well will be assigned a unique location identifier.

Sample year: Year the sample was collected (09 or 10).

Round: Round the groundwater sample was collected (01 or 02).

Example: A groundwater sample collected from well 13MW19 in Zone 1 during Round 01 of the PDI in 2010 will be identified as: LS1-GW-13MW19-10-01.

QC Samples collected during a sampling program typically use the same coding system as the environmental samples. Duplicates are the only QC samples that will be collected for this project. These samples will be identified with "-D" following the coding.

Sample Collection Documentation

A project-specific field logbook will be used to keep daily records of significant events, observations, and measurements during field investigations. The field logbook also will be used to document all sampling activities. Logbook entries will be made with indelible ink to provide a permanent record, and any errors in the logbook will be verified, crossed through, and initialed by the person discovering the error. Field logbooks will be maintained according to Tetra Tech SOP No. SA-6.3 (Appendix A). The field logbooks

are intended to provide sufficient data and observations to reconstruct events that occurred during field activities. Field logbooks should be permanently bound and pre-paginated; designated forms should be used whenever possible to ensure that field records are complete. The following items are examples of information that may be included in a field logbook:

- Name, date, and time of entry
- Names and responsibilities of field crew members
- Name and titles of any site visitors
- Descriptions of field procedures, and problems encountered
- Samples collected at each location
- Details of sampling location, including sampling coordinates
- Sample identification numbers of all samples collected
- Date and time of collection
- Sample collector
- Sample collection method
- Decontamination procedures
- Weather conditions
- Site observations
- Site sketches
- Health and Safety issues including personal protective equipment
- Log of photographs

Field sample log sheets will be used to document sample collection details, and other observations and activities will be recorded in the field logbook. The following sections outline the information that will be documented in the field according to the medium to be sampled and the activities to be performed. Examples of these forms can be found in Appendix B.

Field Sample Handling and Chain-of Custody Procedures

Custody of samples must be maintained and documented at all times to ensure the integrity of each sample from collection through analysis. An accurate written record is necessary to trace the possession and handling of the sample; this documentation is referred to as the "chain of custody" form. Chain of custody begins when samples are collected in the field and is maintained by storing the samples in secure areas until custody can be passed on. All samples will be delivered to the laboratory accompanied by a chain-of-custody form that will describe the sample identifiers, dates and times of sample collection, analytical parameters, and persons responsible for the sample integrity.

Prior to sample collection, sample containers will be labeled with the sample location number, sampler's name, date, and analytical fraction. Following collection, samples will be placed in a secure cooler and attended by Tetra Tech personnel or placed in locked vehicles or designated storage areas until shipment to an off-site laboratory. Chain-of-custody procedures are described in further detail in Tetra Tech SOPs: SA-6.3, Field Documentation, and SA-6.1, Non-Radiological Sample Handling (Appendix A).

The samples will be shipped to the laboratory in coolers packed with bubble wrap, or equivalent packing material, to cushion the samples and prevent breakage. The coolers will be taped and sealed with a signed custody seal to ensure that chain of custody is maintained. Samples will be shipped to the laboratory by their courier service to ensure that maximum sample holding times are not exceeded. The maximum allowable sample holding times for each analysis are presented in Worksheet #19. This worksheet also lists the sample containers and chemical preservatives required to maintain the integrity of the sample.

Each sample collected will be assigned a unique sampling tracking number, as described above. The sample number, sample collection date and time, and a list of the sample analyses to be performed will be recorded on each container and also on the chain-of-custody form. The chain-of-custody form is a two-part form: the original accompanies the samples to the analytical laboratory, and the copy will be archived in the project files. The following information will be recorded on the chain-of-custody form:

- Project name and number
- Sample matrix
- Sample collector's name
- Dates/times of sample collection
- Sample identification numbers
- Number and type of containers for each sample aliquot
- Type of preservation
- QC sample designation
- Analysis method
- Special handling instructions
- Destination of samples
- Name, date, time, and signature of each individual releasing the shipping container

The field crew will attempt to identify any potentially high concentration samples on the chain-of-custody form.

Laboratory Custody Procedures

Upon receipt of samples at the CAS sample management office (SMO), a cooler receipt and preservation check form is used to assess the shipping cooler and its contents as received by the laboratory personnel. The samples are logged in to the Laboratory Information Management System (LIMS) based on the chain of custody documentation provided. The sample containers are uniquely labeled and stored in the appropriate storage locations. An internal chain of custody is created and maintained throughout the samples lifecycle.

SAP Worksheet #28 -- Laboratory QC Samples Table
(UFP-QAPP Manual Section 3.4)

Matrix	Aqueous
Analytical Group	Metals
Analytical Method / SOP Reference	1640 (preparation) and 6020 (analytical)/ Lab SOP 1 and SOP 2

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per batch or 1 per 20 samples	No target analytes > QL.	Investigate contamination. Redigest and reanalyze. If sample concentration is >20X blank concentration, narrate.	Chemist/Analyst	Bias/Contamination	No target analytes > QL.
Laboratory Control Sample	1 per batch or 1 per 20 samples	Arsenic 71-124% Copper 63-128% Lead 82-113%	Redigest and reanalyze. Describe in Case Narrative of data package if recovery is high and sample is <QL.	Chemist/Analyst	Accuracy/Bias/ Contamination	%Recovery
Duplicate Sample	1 per 20 samples	RPD <=20%	Qualify data.	Chemist/Analyst	Precision	RPD <=20%
Matrix Spike	1 per 20 samples	Arsenic 50-147% Copper 50-120% Lead 55-118%	Perform post-digestion spike analysis, qualify data.	Chemist/Analyst	Accuracy/Bias	%Recovery

Matrix	Aqueous					
Post-digestion Spike	For compounds outside of QC limits in Matrix Spike	%Recovery 75% - 125%	Qualify data.	Chemist/Analyst	Accuracy/Bias	%Recovery 75% - 125%
ICP Serial Dilution	Per analytical run	%Difference 90% - 110%	Qualify data	Chemist/Analyst	Accuracy / Bias	%Difference 90% - 110%

SAP Worksheet #29 -- Project Documents and Records Table

(UFP-QAPP Manual Section 3.5.1)

Document[1]	Where Maintained
Sample Collection Documents and Records • Field logbook (and sampling notes) • Field sample forms (e.g., sample log sheets, drilling logs, etc.) • Chain-of-custody records • Sample shipment airbills • Photographs • Field Task Modification Forms • Sampling and Analysis Plan • Field Sampling SOPs • Boring Logs	Tetra Tech project file, results will be discussed in subject document.
Laboratory Documents and Records • Sample receipt/login form • Sample storage records • Sample preparation logs • Standard traceability logs • Equipment calibration logs • Sample analysis run logs • Equipment maintenance, testing, and inspection logs • Corrective action forms • Reported field sample results • Reported results for standards, quality control checks, and quality control samples • Data completeness checklists • Sample storage and disposal records • Telephone logs • Extraction/clean-up records • Raw data	Tetra Tech Project File, long-term data package storage at third-party professional document storage firm (Business Records Management, Inc.), results will be discussed in subject document.
Data Assessment Documents and Records • Field Sampling Audit Checklist (if an audit is conducted) • Analytical Audit Checklist (if an audit is conducted) • Data Validation Memoranda	Tetra Tech project file, results will be discussed in subject document.

1 See last part of Worksheet #14 for description of document tracking and control process.

SAP Worksheet #30 -- Analytical Services Table
(UFP-QAPP Manual Section 3.5.2.3)

Matrix	**Analytical Group**	**Sample Locations/ID Number**	**Analytical Method**	**Data Package Turnaround Time**	**Laboratory / Organization** (name and address, contact person and telephone number)	**Backup Laboratory / Organization** (name and address, contact person and telephone number)
Aqueous	Metals	See Worksheet #18	EPA 1640 (preparation) and 6020 (analytical)	21 days	Lynda Huckestein Client Services Manager Columbia Analytical Services, Inc. 1317 S. 13th Ave. Kelso, WA 98626 360-577-7222	Not applicable

SAP Worksheet #31 -- Planned Project Assessments Table
(UFP-QAPP Manual Section 4.1.1)

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment (title and organizational affiliation)	Person(s) Responsible for Responding to Assessment Findings (title and organizational affiliation)	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA) (title and organizational affiliation)	Person(s) Responsible for Monitoring Effectiveness of CA (title and organizational affiliation)
Field Sampling System Audit	1 per contract year	Internal	Tetra Tech	Person assigned by Tetra Tech QAM	Tetra Tech PM and FOL	Tetra Tech Auditor and PM	Tetra Tech CLEAN QAM
Laboratory System Audit(1)	Every 3 years	External	DOD ELAP Accrediting Body	Accrediting Body	Laboratory QAM or Laboratory Manager	Laboratory QAM or Laboratory Manager	Laboratory QAM or Laboratory Manager

1. CAS has successfully completed the DOD ELAP evaluation process as described in the DOD QSM. The DOD ELAP certification letter is included in Appendix C.

SAP Worksheet #32 -- Assessment Findings and Corrective Action Responses
(UFP-QAPP Manual Section 4.1.2)

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (name, title, organization)	Time Frame of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (name, title, organization)	Time Frame for Response
Field Sampling System Audit (1)	Audit checklist (as per Navy Installation Restoration Chemical Data Quality Manual [IRCDQM]) and written audit report	Corey Rich, PM, Tetra Tech; TBD, FOL, Tetra Tech; John Trepanowski Program Manager; Garth Glenn, Deputy Program Manager, Tetra Tech	Dependent on the finding; if major, a stop work may be issued immediately; however, if minor within 1 week of audit	Written memo	Corey Rich, PM, Tetra Tech; TBD, FOL, Tetra Tech; John Trepanowski Program Manager; Garth Glenn, Deputy Program Manager, Tetra Tech	Within 48 hours of notification
Laboratory System Audit	Written audit report	Lab QAM	Not specified by	Letter	DOD Accrediting Body	Not Specified by DOD

1 Audits are scheduled at the Tetra Tech program level and may or may not include this project.

SAP Worksheet #33 -- QA Management Reports Table

(UFP QAPP Manual Section 4.2)

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (title and organizational affiliation)	Report Recipient(s) (title and organizational affiliation)
Data Validation Report	Per sample delivery group (SDG)	Once validation is complete	Tetra Tech DVM or designee	Tetra Tech PM, project file
Major Analysis Problem Identification (internal memo)	When persistent analysis problems are detected	Immediately	Tetra Tech Program QAM	Tetra Tech PM, Program QAM, Program Manager, and project file
Project Monthly Progress Report	Monthly for duration of project	Monthly	Tetra Tech PM	Navy, project file
Laboratory QA Report	When significant plan deviations result from unanticipated circumstances	Immediately	Laboratory PM	Tetra Tech PM, project file

SAP Worksheet #34 -- Verification (Step I) Process Table
(UFP-QAPP Manual Section 5.2.1)

Verification Input	Description	Internal/ External	Responsible for Verification (name, organization)
Chain-of-Custody Forms	The Tetra Tech FOL or designee will review and sign the chain-of-custody forms to verify that all samples listed are included in the shipment to the laboratory and that the sample information is accurate. The forms will be signed by the sampler and a copy will be retained for the project file and the Tetra Tech PM. See SOP SA-6.3.	Internal	Tetra Tech sampler and FOL
SAP Sample Tables	Verify that all proposed samples listed in the SAP tables have been collected.	Internal	Tetra Tech FOL or designee
Sample Log Sheets	Verify that information recorded in the log sheets is accurate and complete.	Internal	Tetra Tech FOL or designee
Sample Coordinates	Verify that sample locations are correct and in accordance with the SAP proposed locations.	Internal	Tetra Tech FOL or designee
Field QC Samples	Check that field QC samples listed in Worksheet #20 were collected as required.	Internal	Tetra Tech, FOL or designee
Chain-of-Custody Forms	The laboratory sample custodian will review the sample shipment for completeness and integrity and will sign accepting the shipment. The Tetra Tech data validator will check that the chain-of-custody form was signed/dated by the Tetra Tech FOL or designee relinquishing the samples and also by the laboratory sample custodian receiving the samples for analyses.	External/ Internal	Laboratory sample custodian/ Tetra Tech data validator
Analytical Data Package	All analytical data packages will be verified internally for completeness by the laboratory performing the work. The Laboratory QAM will sign the case narrative for each data package.	Internal	Laboratory QAM, Columbia Analytical Services
Analytical Data Package	The data package will be verified for completeness by Tetra Tech data validator. Missing information will be requested from the laboratory.	External	Tetra Tech data validator

Verification Input	Description	Internal/ External	Responsible for Verification (name, organization)
Electronic Data Deliverables (EDDs)	The electronic data will be verified against the chain-of-custody and hard copy data package for accuracy and completeness. Laboratory analytical results will be verified and compared to the electronic analytical results for accuracy. Sample results will be evaluated for laboratory contamination and will be qualified for false positives using the laboratory method/preparation blank summaries. Positive results reported between the method detection limit and reporting limit will be qualified as estimated. Extraneous laboratory qualifiers will be removed from the validation qualifier.	External	Tetra Tech data validator

SAP Worksheet #35 -- Validation (Steps IIa and IIb) Process Table
(UFP-QAPP Manual Section 5.2.2) (Figure 37 UFP-QAPP Manual) (Table 9 UFP-QAPP Manual)

Step IIa / IIb[1]	Validation Input	Description	Responsible for Validation (name, organization)
IIa	Field SOPs/Field Logs/Sample Collection Logs	Ensure that all sampling SOPs were followed. Verify that deviations have been documented and measurement performance criteria (MPC) have been achieved. Particular attention should be given to verify that samples were correctly identified, that sampling location coordinates are accurate, and that documentation establishes an unbroken chain-of-custody from sample collection to report generation. Verify that the correct sampling and analytical methods/SOPs were applied. Verify that the sampling plan was implemented and carried out as written and that any deviations are documented.	Tetra Tech PM or designee
IIa	Chain-of-Custody Forms	Ensure that the custody and integrity of the samples were maintained from collection to analysis and that the custody records are complete and any deviations are recorded.	Tetra Tech Project Chemist or data validators
IIa	Holding Times	Review that the samples were shipped and stored at the required temperature and sample pH for chemically-preserved samples meet the requirements as listed in Worksheet #19. Ensure that the analyses were performed within the holding times listed in Worksheet #19.	Tetra Tech Project Chemist or data validators
IIa/IIb	Laboratory Data Results for Accuracy	Ensure that the laboratory QC samples listed in Worksheet #28 were analyzed and that the MPC listed in Worksheet #12 were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed and that the analytical QC criteria set up for this project were met.	Tetra Tech Project Chemist or data validators
IIa/IIb	Laboratory Duplicate Analyses for Precision	Check the laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses, MS/MSDs, and LCS/LCSDs. Ensure compliance with the methods and project MPC accuracy goals listed in Worksheet #12.	Tetra Tech Project Chemist or data validators
IIa/IIb	Sample Results for Representativeness	Check that the laboratory recorded the temperature at sample receipt and the pH of the chemically preserved samples to ensure sample integrity from sample collection to analysis.	Tetra Tech Project Chemist or data validators

Step IIa / IIb[1]	Validation Input	Description	Responsible for Validation (name, organization)
IIa/IIb	Project Action Limits (PALs)	Discuss the impact on matrix interferences or sample dilutions performed because of the high concentration of one or more contaminants on the other target compounds reported as no-detected. Document this usability issue and inform the PM.	Tetra Tech Project Chemist or data validators
IIa/IIb	Data Validation Report	Summarize deviations from methods, procedures, or contracts. Qualify data results based on method or QC deviation and explain all data qualifications. Print a copy of the project database qualified data depicting data qualifiers and data qualifiers codes that summarize the reasons for data qualifications. Determine if the data met the MPCs and determine the impact of any deviations on the technical usability of the data.	Tetra Tech Project Chemist or data validators
IIa, IIb	SAP QC Sample Documentation	Ensure that all QC samples specified in the SAP were collected and analyzed and that the associated results were within prescribed SAP acceptance limits. Ensure that QC samples and standards prescribed in analytical SOPs were analyzed and within the prescribed control limits. If any significant QC deviations occur, the laboratory shall have contacted the Tetra Tech PM.	Tetra Tech PM or designee
IIa, IIb	Documentation of Analytical Reports for Completeness	Review the chain-of-custody form generated in the field to ensure that the required analytical samples have been collected, appropriate sample identifications have been used, and correct analytical methods have been applied. Validator will verify that elements of the data package required for validation are present, and if not, the laboratory will be contacted and the missing information will be requested. Validation will be performed as per Worksheet #36. Check that all data have been transferred correctly and completely to the final Structured Query Language (SQL) database.	Tetra Tech Project Chemist or data validators
IIa/IIb	PALs	Review and add PALs to the laboratory EDD. Flag samples and notify PM of samples that exceed PALs, as listed on Worksheet #15.	Tetra Tech PM or designee
IIb	QLs for Sensitivity	Ensure that the QLs listed in Worksheet #15 were achieved.	Tetra Tech Project Chemist or data validators
IIb	Analytical Data Deviations	Determine the impact of any deviation from sampling or analytical methods and SOPs requirements and matrix interferences effect on the analytical results.	Tetra Tech Project Chemist or data validators

1 IIa=compliance with methods, procedures, and contracts [see Table 10, page 117, UFP-QAPP manual, V.1, March 2005].
IIb=comparison with measurement performance criteria in the SAP [see Table 11, page 118, UFP-QAPP manual, V.1, March 2005].

SAP Worksheet #36 –Analytical Data Validation (Steps IIa and IIb) Summary Table
(UFP-QAPP Manual Section 5.2.2.1)

Step IIa/IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
IIa/IIb	Aqueous	Metals	EPA Region 1 Tier III data validation. Criteria for SW-846 6020 and EPA 1640 listed in Worksheet #s 12, 15, 24, and 28. If not included in Worksheet #s 12, 15, 24, or 28, the logic outlined in to Region 1, EPA-NE Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses, modified February 1989, will be used to apply qualifiers to data.	Tetra Tech Data Validation Coordinator (Joseph Samchuck) and staff chemists

SAP Worksheet #37 -- Usability Assessment
(UFP-QAPP Manual Section 5.2.3)

Data Usability Assessment

The usability of the data directly affects whether project objectives can be achieved. The following characteristics will be evaluated at a minimum. The results of these evaluations will be included in the project report. The characteristics will be evaluated for multiple concentration levels if the evaluator determines that this is necessary. To the extent required by the type of data being reviewed, the assessors will consult with other technically competent individuals to render sound technical assessments of these data characteristics:

- **Completeness:** For each matrix that was scheduled to be sampled, the FOL acting on behalf of the project team will prepare a table listing planned samples/analyses to collected samples/analyses. If deviations from the scheduled sample collection or analyses are identified, the Tetra Tech PM will determine whether the deviations compromise the ability to meet project objectives. If they do, the Tetra Tech PM will consult with the Navy RPM and other project team members, as necessary (determined by the Navy RPM), to develop appropriate corrective actions.

- **Precision:** The Project Chemist acting on behalf of the project team will determine whether precision goals for field duplicates and laboratory duplicates were met. This will be accomplished by comparing duplicate results to precision goals identified in Worksheets #12 and #28. This will also include a comparison of field and laboratory precision with the expectation that the field duplicate results will be no less precise than laboratory duplicate results. If the goals are not met, or data have been flagged as estimated (*J qualifier), limitations on the use of the data will be described in the project report.

- **Accuracy:** The Project Chemist acting on behalf of the project team will determine whether the accuracy/bias goals were met for project data. This will be accomplished by comparing percent recoveries of LCS, LCSD, and MS to accuracy goals identified in Worksheet #28. This assessment will include an evaluation of laboratory contamination; instrument calibration variability; and analyte recoveries for matrix spike, and laboratory control samples. If the goals are not met, limitations on the use of the data will be described in the project report. Bias of the qualified results and a description of the impact of identified non-compliances on a specific data package or on the overall project data will be described in the project report.

- **Representativeness:** A project scientist identified by the Tetra Tech PM and acting on behalf of the project team will determine whether the data are adequately representativeness of intended populations, both spatially and temporally. This will be accomplished by verifying that samples were collected and processed for analysis in accordance with the SAP, be reviewing spatial and temporal data variations, and by comparing these characteristics to expectations. The usability report will describe the representativeness of the data for each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the project scientist indicates that a quantitative analysis is required.

- **Comparability:** The Project Chemist acting on behalf of the project team will determine whether the data generated under this project are sufficiently comparable to historical site data generated by different methods and for samples collected using different procedures and under different site conditions. This will be accomplished by comparing overall precision and bias among data sets for each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the Project Chemist indicates that such quantitative analysis is required.

- **Sensitivity:** The Project Chemist acting on behalf of the project team will determine whether project sensitivity goals listed in Worksheet #15 are achieved. The overall sensitivity and quantitation limits from multiple data sets for each matrix and analysis will be compared. If sensitivity goals are not achieved, the limitations on the data will be described. The Project Chemist will enlist the help of the project risk assessor to evaluate deviations from planned sensitivity goals.

Data Usability Assessment

- **Project Assumptions and Data Outliers**
  The Tetra Tech Project Manager and designated team members will evaluate whether project assumptions are valid. This will typically be a qualitative evaluation but may be supported by quantitative evaluations. The type of evaluation depends on the assumption being tested. During this evaluation, the team will consider whether outliers could be indications of unanticipated site conditions.

Describe the evaluative procedures used to assess overall measurement error associated with the project:

After completion of the data validation, the data and data quality will be reviewed to determine whether sufficient data of acceptable quality are available for decision making. In addition to the evaluations described above, a series of inspections and analyses will be performed to estimate these characteristics. The evaluations will include simple summary statistics for target analytes, such as maximum concentration, minimum concentration, number of samples exhibiting non-detected results, number of samples exhibiting positive results, and the proportion of samples with detected and non-detected results. The project team members identified by the project manager will assess whether the data collectively support the attainment of project objectives. They will consider whether any missing or rejected data have compromised the ability to make decisions or to make the decisions with the desired level of confidence. The data will be evaluated to determine whether missing or rejected data can be compensated by other data. Although rejected data will generally not be used, there may be reason to use them in a weight of evidence argument, especially when they supplement data that have not been rejected. If rejected data are used, their use will be supported by technically defensible rationales.

For mathematical manipulations, non-detected values will be represented by a concentration equal to one-half the sample-specific reporting limit. Duplicate results (original and duplicate) will not be averaged for the purpose of representing the range of concentrations. However, the average of the original and duplicate samples will be used to represent the concentration at a particular sampled location.

Identify the personnel responsible for performing the usability assessment:

The Tetra Tech Project Manager, Project Chemist, FOL, and project Scientist will be responsible for conducting the listed data usability assessments. The data usability assessment will be reviewed with the Navy RPM, NSB-NLON Environmental Restoration Program Manager, EPA RPM, and the State of Connecticut Project Manager. If deficiencies affecting the attainment of project objectives are identified, the review will take place either in a face to face meeting or a teleconference depending on the extent of identified deficiencies. If no significant deficiencies are identified, the data usability assessment will simply be documented in the project report and reviewed during the normal document review cycle.

Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

The data will be presented in tabular format, including data qualifications such as estimation (J, UJ) or rejection (R). Written documentation will support the non-compliant estimated or rejected data results. The project report will identify and describe the data usability limitations and suggest re-sampling or other corrective actions, if necessary.

TABLE 10-1

SELECTION OF WELLS FOR ADDITIONAL GROUNDWATER MONITORING
LOWER SUBASE, NSB-NLON, GROTON, CONNECTICUT

Wells	Distance to River (ft)	Historical Groundwater Monitoring Results							Rationale for Selection
		COC	Sample	Phase 1 1991	AESSI95 1993	Phase 2-1 1994	Phase 2-2 1994	LS RI 1997	
Zone 1									
13MW19	146	Arsenic	Total	NA	NA	**13.9 J**	2.6	4.6 J	Historical reported concentrations of arsenic, copper, and lead greater than their SWPCs. Also closest to river.
			Dissolved	NA	NA	**24.8 J**	2.3	5.2	
		Copper	Total	NA	NA	**68.4 J**	5 U	6.3	
			Dissolved	NA	NA	44.2	5 U	5 U	
		Lead	Total	NA	NA	**39.3 J**	2 UJ	2.4 J	
			Dissolved	NA	NA	12.8	2 UJ	2.1 J	
13MW20	231	Arsenic	Total	NA	NA	2 UJ	2.7	**12.4**	Historical reported concentrations of arsenic, copper, and lead greater than their SWPCs.
			Dissolved	NA	NA	2 UJ	2 J	**11.3**	
		Copper	Total	NA	NA	5.35 J	5 U	**156**	
			Dissolved	NA	NA	3.9 J	5 U	**120**	
		Lead	Total	NA	NA	4.9 J	2.6 J	**55.7**	
			Dissolved	NA	NA	2 U	2 UJ	**36.3**	
13MW21	157.5	Arsenic	Total	NA	NA	**16.8 J**	1.8 J	9.1	Historical reported concentrations of arsenic, copper, and lead greater than their SWPCs. Also closest to river.
			Dissolved	NA	NA	**12.8 J**	2	8.6	
		Copper	Total	NA	NA	**53.3 J**	5 U	16.9	
			Dissolved	NA	NA	20.6	5 U	15.6	
		Lead	Total	NA	NA	**36.1**	2 J	**27.4**	
			Dissolved	NA	NA	**13.5**	2 UJ	**21.9**	
FOMW14	405	Arsenic	Total	NA	NA	NA	NA	6.5	Historical reported concentrations of copper and lead greater than their SWPC.
			Dissolved	NA	NA	NA	NA	4.2 J	
		Copper	Total	NA	NA	NA	NA	**77.9**	
			Dissolved	NA	NA	NA	NA	14.8	
		Lead	Total	NA	NA	NA	NA	**36.8**	
			Dissolved	NA	NA	NA	NA	2.4 J	
13MW7	60	Arsenic	Total	3 U	NA	NA	NA	NA	Closest to river.
			Dissolved	NA	NA	NA	NA	NA	
		Copper	Total	9.95	NA	NA	NA	NA	
			Dissolved	NA	NA	NA	NA	NA	
		Lead	Total	2.4 J	NA	NA	NA	NA	
			Dissolved	NA	NA	NA	NA	NA	

TABLE 10-1

SELECTION OF WELLS FOR ADDITIONAL GROUNDWATER MONITORING
LOWER SUBASE, NSB-NLON, GROTON, CONNECTICUT

Wells	Distance to River (ft)	Historical Groundwater Monitoring Results							Rationale for Selection
		COC	Sample	Phase 1 1991	AESSI95 1993	Phase 2-1 1994	Phase 2-2 1994	LS RI 1997	
Zone 4									
13MW13	160	Arsenic	Total	4.5	NA	9.3 J	**13.6**	**21.4**	Historical reported concentrations of arsenic greater than its SWPC.
			Dissolved	NA	NA	2 UJ	**11.6.U**	**14.7**	
13MW14	50	Arsenic	Total	3 U	NA	2 U	10 U	2.5 U	Closest to river.
			Dissolved	NA	NA	2 U	20 U	2.5 U	
13MW15	25	Arsenic	Total	3 U	NA	20 UJ	**11 J**	2.5 U	Historical reported concentration of arsenic greater than its SWPC. Also closest to river.
			Dissolved	NA	NA	20 UJ	20 U	2.5 U	
NESO10	50	Arsenic	Total	3 U	NA	5.4 J	**19**	2.8 J	Historical reported concentrations of arsenic greater than its SWPC. Also closest to river.
			Dissolved	NA	NA	2 UJ	**11**	3.1 J	
NESO11	170	Arsenic	Total	3 U	NA	**17.1 J**	1.3 J	3.1 J	Historical reported concentration of arsenic greater than its SWPC.
			Dissolved	NA	NA	2 UJ	1 U	2.5 U	
WE 5 **(destroyed)**	80	Arsenic	Total	5.2	NA	**29.6 J**	**11.8**	NA	Historical reported concentrations of arsenic greater than its SWPC. Sufficient number of other Zone 4 wells so well does not need to be re-installed.
			Dissolved	NA	NA	2.3 J	4.9	NA	
Zone 5									
19MW3	50	Arsenic	Total	NA	4.3 U	NA	NA	2.5 U	Closest to river.
			Dissolved	NA	2 U	NA	NA	2.5 U	
19MW4 **(destroyed)**	80	Arsenic	Total	NA	**30.2 UW**	NA	NA	NA	Historical reported concentrations of arsenic greater than its SWPC. Well will be re-installed.
			Dissolved	NA	**34.3**	NA	NA	NA	

TABLE 10-1

SELECTION OF WELLS FOR ADDITIONAL GROUNDWATER MONITORING
LOWER SUBASE, NSB-NLON, GROTON, CONNECTICUT

Wells	Distance to River (ft)	Historical Groundwater Monitoring Results							Rationale for Selection
		COC	Sample	Phase 1 1991	AESSI95 1993	Phase 2-1 1994	Phase 2-2 1994	LS RI 1997	
Zone 7									
20MW7	70	Arsenic	Total	NA	3.9 U	NA	NA	**18.8**	Historical reported concentrations of arsenic greater than its SWPC. Also closest to river.
			Dissolved	NA	4.9 U	NA	NA	**20**	
MW3-7RI	45	Arsenic	Total	NA	NA	NA	NA	2.5 U	Closest to river.
			Dissolved	NA	NA	NA	NA	2.5 U	
MW4-7RI	90	Arsenic	Total	NA	NA	NA	NA	**11**	Historical reported concentration of arsenic greater than its SWPC. Also closest to river.
			Dissolved	NA	NA	NA	NA	8.9	

NOTES:

All analytical results are in micrograms per liter (µg/L).
Highlighting signifies that detected concentration is greater than the Alternative Surface Water Protection Criterion (SWPC) for arsenic (10 µg/L), the SWPC for copper (48 µg/L),a nd the SWPC for lead (13 µg/L).

B: Blank contamination
J: Estimated value
NA: Not analyzed
U: Undetected at the indicated analytical detection limit

TABLE 10-2

GROUNDWATER GEOCHEMICAL DATA FOR WELLS WITH METALS CONCENTRATIONS GREATER THAN SWPC
LOWER SUBASE GROUNDWATER PRE-DESIGN INVESTIGATION
NSB-NLON, GROTON, CONNECTICUT

Zone	Well	Phase 1 RI		AESSI95		Phase 2 RI - Round 1		Phase 2 RI- Round 2		Lower Subase RI	
		Salinity	Turbidity	Salinity	Turbidity	Salinity	Turbidity	Salinity	Turbidity	Salinity	Turbidity
		(g/L)	(NTU)	(g/L)	(NTU)	(g/L)	(NTU)	(g/L)	(NTU)	(g/L)	(NTU)
1(1)	13MW19	NA	NA	NA	NA	**0.9**	**26**	0.7	ER	0.67	6.3
	13MW20	NA	NA	NA	NA	0.5	19	0.4	ER	**2.65**	**18**
	13MW21	NA	NA	NA	NA	**0.7**	**43**	0.2	ER	**1.03**	**19**
	FOMW14	NA	NA	NA	NA	NA	NA	NA	NA	**0.53**	**30.7**
	13MW7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4(2)	13MW13	NA	NA	NA	NA	0.2	26	0.2	ER	0.34	18
	13MW14	NA	NA	NA	NA	9.1	0	17	ER	11.9	0.89
	13MW15	NA	NA	NA	NA	18.6	70	**20.8**	**ER**	21.9	5.91
	NESO10	NA	NA	NA	NA	3.5	3	**5.3**	**16**	3.26	18
	NESO11	NA	NA	NA	NA	0.3	221	0.2	ER	0.26	1.9
	WE5	NA	NA	NA	NA	0.1	291	0.2	7	NA	NA
5(3)	19MW3	NA	NA	NA	NA	NA	NA	NA	NA	0.35	6.08
	19MW4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7(4)	20MW7	NA	NA	NA	NA	NA	NA	NA	NA	**0.25**	**1.59**
	MW3-7RI	NA	NA	NA	NA	NA	NA	NA	NA	0.39	1.45
	MW4-7RI	NA	NA	NA	NA	NA	NA	NA	NA	**0.31**	**1.63**

Highlighting denotes metal (arsenic, copper, or lead) concentration detected in individual well was greater than SWPC.
(1) - Total and dissolved arsenic, total copper, and total lead in 13MW19 and total and dissolved arsenic, total copper, and total and dissolved lead in 13MW21 were greater than SWPC during Phase 2 RI - Round 1. Total and dissolved arsenic, copper, and lead in 13MW20, total and dissolved lead in 13MW21, and total copper and lead were greater than SWPC during Lower Subase RI.
(2) - Total arsenic in NESO11 and WE5 were greater than SWPC during Phase 2 RI - Round 1. Total and dissolved arsenic in 13MW13, total arsenic in 13MW15, total and dissolved arsenic in NESO10, and total arsenic in WE 5 were greater than SWPC during Phase 2 RI - Round 2. Total and dissolved arsenic in 13MW13 were greater than SWPC during Lower Subase RI. Also, high analytical detection limits during Phase 2 RI - Rounds 1 and 2.
(3) - Dissolved arsenic in 19MW4 greater than SWPC during AESSI95. Also, high analytical detection limit for total arsenic in 19MW4 during AESSI95.
(4) - Total and dissolved arsenic in 20MW7 and total arsenic in MW4-7RI greater than Alternative SWPC during Lower Subase RI.

TABLE 10-2

GROUNDWATER GEOCHEMICAL DATA FOR WELLS WITH METALS CONCENTRATIONS GREATER THAN SWPC
LOWER SUBASE GROUNDWATER PRE-DESIGN INVESTIGATION
NSB-NLON, GROTON, CONNECTICUT

AESSI95 - Pier 33 Site Inspection (1993 sampling)
ER - Equiment Error (Negative reading, e.g., -10 NTU)
g/L - Grams per liter, or part per thousand (ppt)
mV - Millivolts
NA - Not available.
NTU - Nephelometric turbidity unit

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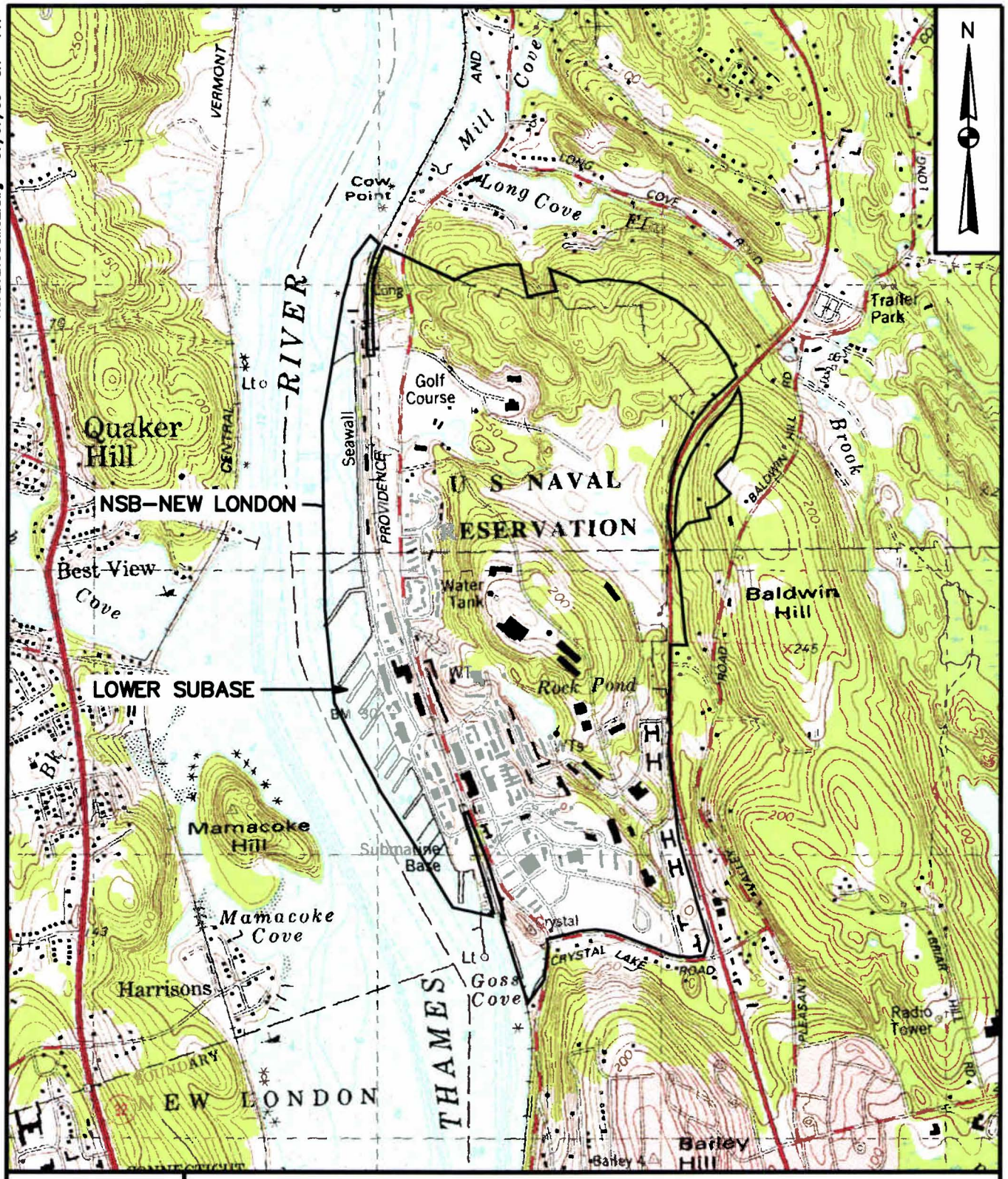


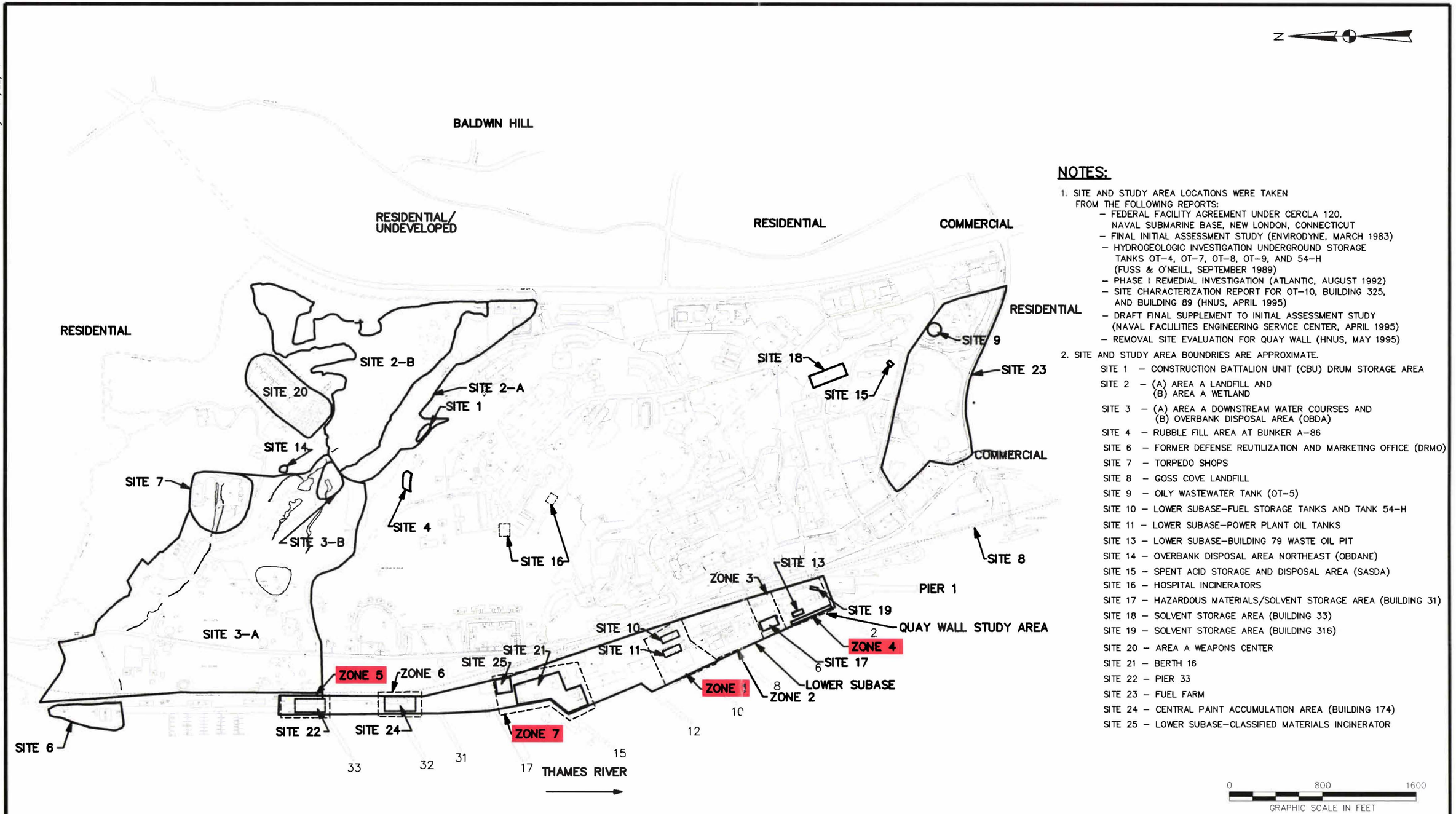
0 2000 4000
GRAPHIC SCALE IN FEET

SOURCE: USGS QUADRANGLE MAP UNCASVILLE, CONNECTICUT, 1984

DRAWN BY CK DATE 7/07/09	Tetra Tech NUS, Inc.	FACILITY LOCATION MAP LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT	CONTRACT NO. 2195
CHECKED BY DATE			OWNER NO. WE24
REVISED BY DATE			APPROVED BY CAR DATE 7/24/09
SCALE AS NOTED			DRAWING NO. FIGURE 10-1 REV. 0

FORM CADD NO. TTNUS-AV.DWG - REV 1 -9/10/98

ACAD: 2195CM01.dwg 07/22/09 CK PIT



NOTES:

1. SITE AND STUDY AREA LOCATIONS WERE TAKEN FROM THE FOLLOWING REPORTS:
   - FEDERAL FACILITY AGREEMENT UNDER CERCLA 120, NAVAL SUBMARINE BASE, NEW LONDON, CONNECTICUT
   - FINAL INITIAL ASSESSMENT STUDY (ENVIRODYNE, MARCH 1983)
   - HYDROGEOLOGIC INVESTIGATION UNDERGROUND STORAGE TANKS OT-4, OT-7, OT-8, OT-9, AND 54-H (FUSS & O'NEILL, SEPTEMBER 1989)
   - PHASE I REMEDIAL INVESTIGATION (ATLANTIC, AUGUST 1992)
   - SITE CHARACTERIZATION REPORT FOR OT-10, BUILDING 325, AND BUILDING 89 (HNUS, APRIL 1995)
   - DRAFT FINAL SUPPLEMENT TO INITIAL ASSESSMENT STUDY (NAVAL FACILITIES ENGINEERING SERVICE CENTER, APRIL 1995)
   - REMOVAL SITE EVALUATION FOR QUAY WALL (HNUS, MAY 1995)
2. SITE AND STUDY AREA BOUNDRIES ARE APPROXIMATE.

SITE 1 – CONSTRUCTION BATTALION UNIT (CBU) DRUM STORAGE AREA
SITE 2 – (A) AREA A LANDFILL AND (B) AREA A WETLAND
SITE 3 – (A) AREA A DOWNSTREAM WATER COURSES AND (B) OVERBANK DISPOSAL AREA (OBDA)
SITE 4 – RUBBLE FILL AREA AT BUNKER A-86
SITE 6 – FORMER DEFENSE REUTILIZATION AND MARKETING OFFICE (DRMO)
SITE 7 – TORPEDO SHOPS
SITE 8 – GOSS COVE LANDFILL
SITE 9 – OILY WASTEWATER TANK (OT-5)
SITE 10 – LOWER SUBASE-FUEL STORAGE TANKS AND TANK 54-H
SITE 11 – LOWER SUBASE-POWER PLANT OIL TANKS
SITE 13 – LOWER SUBASE-BUILDING 79 WASTE OIL PIT
SITE 14 – OVERBANK DISPOSAL AREA NORTHEAST (OBDANE)
SITE 15 – SPENT ACID STORAGE AND DISPOSAL AREA (SASDA)
SITE 16 – HOSPITAL INCINERATORS
SITE 17 – HAZARDOUS MATERIALS/SOLVENT STORAGE AREA (BUILDING 31)
SITE 18 – SOLVENT STORAGE AREA (BUILDING 33)
SITE 19 – SOLVENT STORAGE AREA (BUILDING 316)
SITE 20 – AREA A WEAPONS CENTER
SITE 21 – BERTH 16
SITE 22 – PIER 33
SITE 23 – FUEL FARM
SITE 24 – CENTRAL PAINT ACCUMULATION AREA (BUILDING 174)
SITE 25 – LOWER SUBASE-CLASSIFIED MATERIALS INCINERATOR

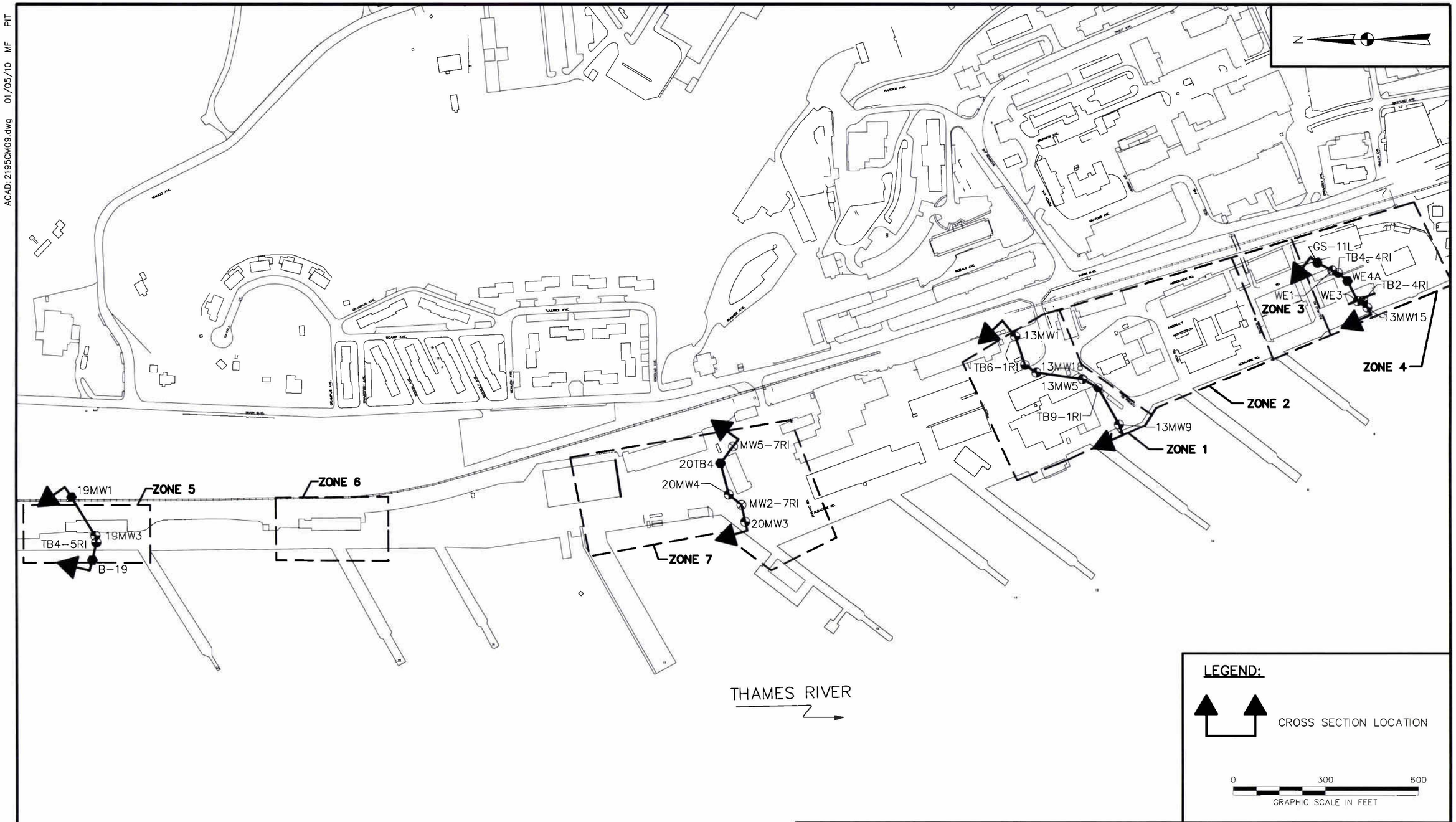
0 800 1600
GRAPHIC SCALE IN FEET

BASE MAP SOURCE: PREPARED BY THE NAVAL SUBMARINE BASE PUBLIC WORKS DEPT., ENGINEERING DIVISION. MARCH 2006, DRAWING NO. A-667.

DRAWN BY CK	DATE 7/22/09	Tetra Tech NUS, Inc.	STUDY AREA LOCATION MAP NSB-NLON, GROTON, CONNECTICUT
CHECKED BY	DATE		
REVISED BY	DATE		
SCALE AS NOTED			

CONTRACT NO. 2195	
OWNER NO. WE24	
APPROVED BY CAR	DATE 7/24/09
DRAWING NO. FIGURE 10-2	REV. 0

ACAD: 2195CM09.dwg 01/05/10 MF PIT



LEGEND:

CROSS SECTION LOCATION

0 300 600

GRAPHIC SCALE IN FEET

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CHECKED BY	DATE		
REVISED BY	DATE		
SCALE AS NOTED			

CONTRACT NO. 2195	
OWNER NO. WE24	
APPROVED BY CAR	DATE 1/8/10
DRAWING NO. FIGURE 10-3	REV. 0

FORM CADD NO. TTNUS-BH.DWG - REV 1 - 9/10/98

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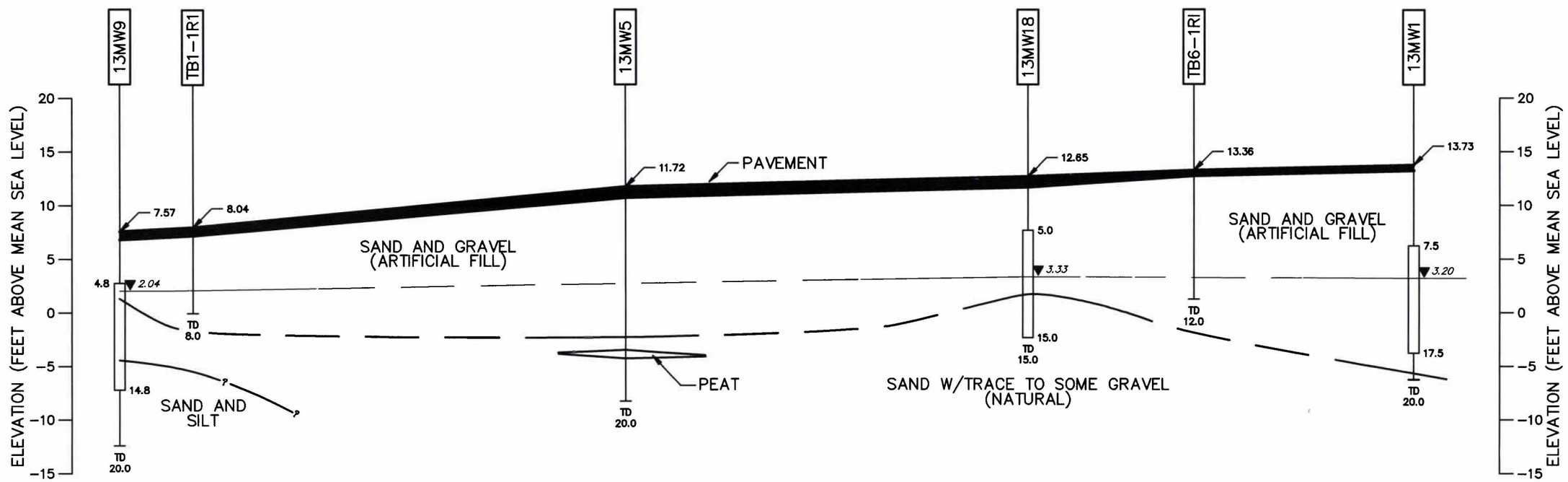

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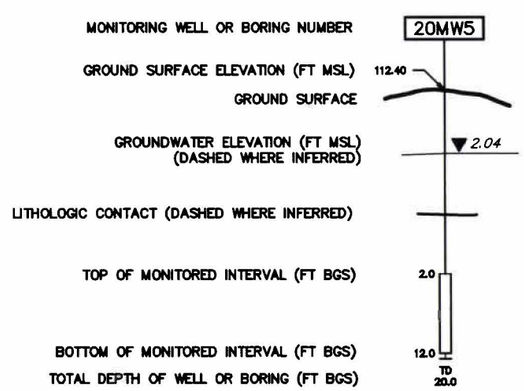
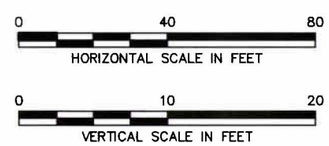




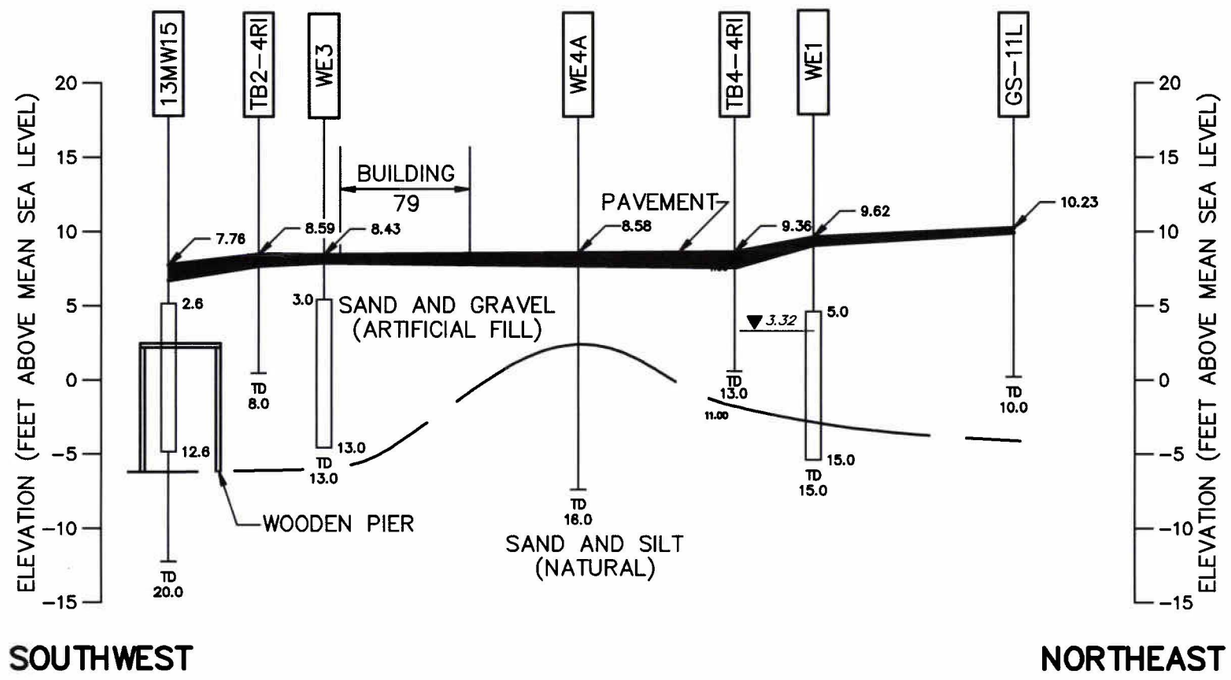
NOTES

1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)

2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997

DRAWN BY CK DATE 7/22/09	Tetra Tech NUS, Inc.	GENERALIZED ZONE 1 GEOLOGICAL CROSS SECTION LOWER SUBASE GROUNDWATER PRE-DESIGN INVESTIGATION NSB-NLON, GROTON, CONNECTICUT	CONTRACT NO. 2195
CHECKED BY DATE			OWNER NO. WE24
REVISED BY DATE			APPROVED BY CAR DATE 1/5/10
SCALE AS NOTED			DRAWING NO. FIGURE 10-4 REV. 0

ACAD: 2195GX02.dwg 01/04/10 CK



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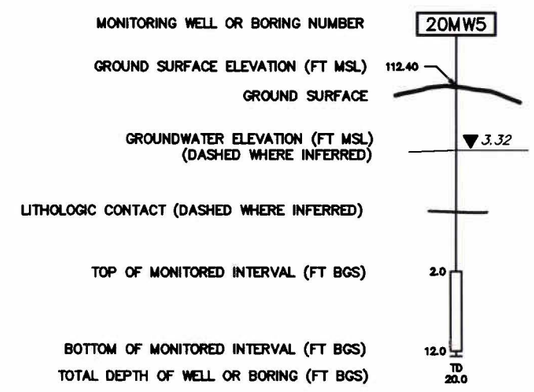
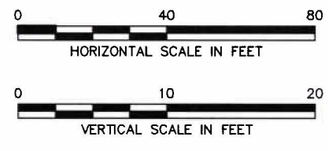




NOTES

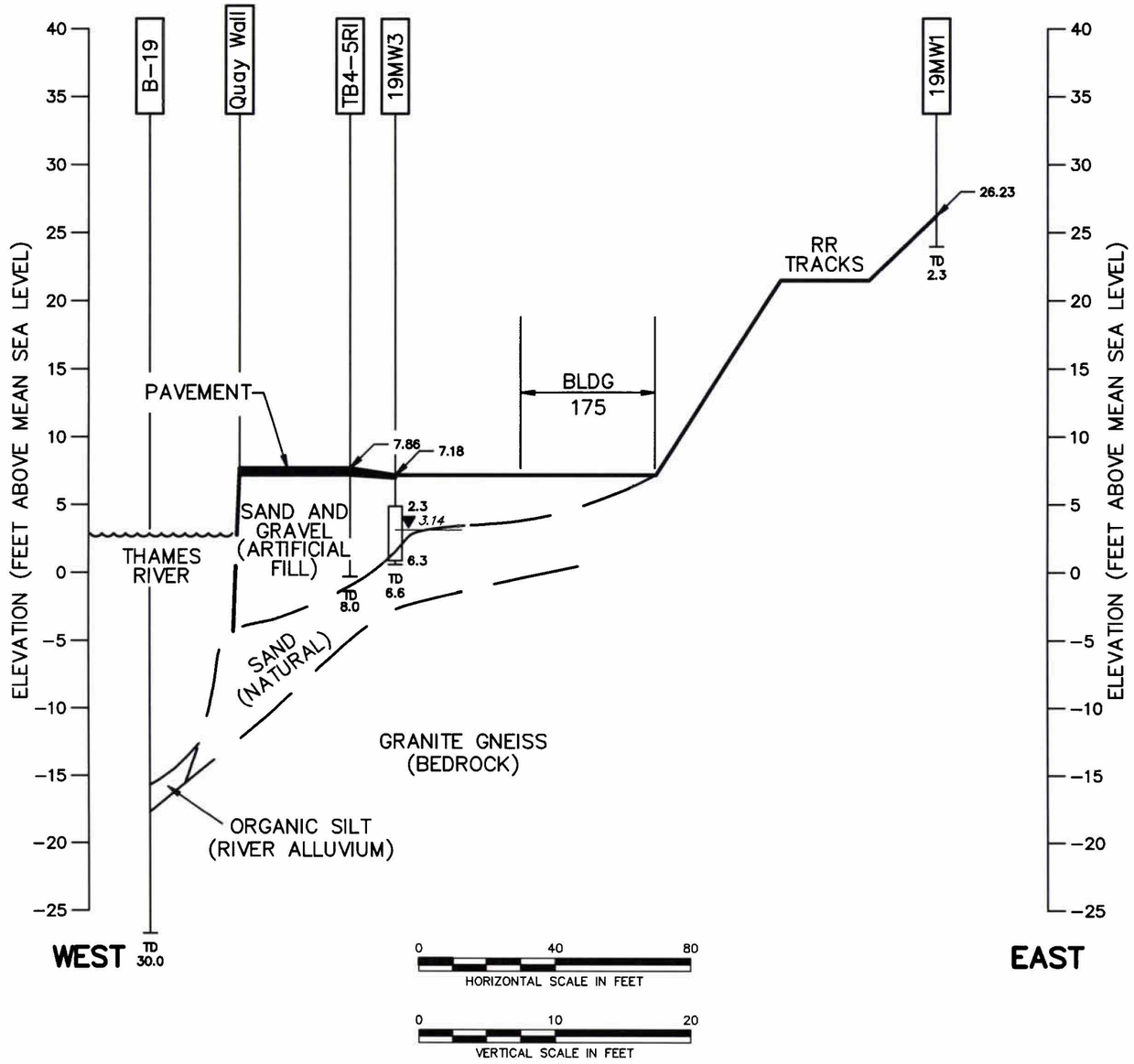
1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)

2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997

3.) WOODEN PIER SUPPPORT LOCATIONS WERE ESTIMATED

DRAWN BY CK DATE 7/22/09	Tetra Tech NUS, Inc.	GENERALIZED ZONE 4 GEOLOGICAL CROSS SECTION LOWER SUBASE GROUNDWATER PRE-DESIGN INVESTIGATION NSB-NLON, GROTON, CONNECTICUT	CONTRACT NO. 2195
CHECKED BY DATE			OWNER NO. WE24
REVISED BY DATE			APPROVED BY CAR DATE 1/8/10
SCALE AS NOTED			DRAWING NO. FIGURE 10-5 REV. 0

ACAD: 2195GX03.dwg 01/04/10 CK



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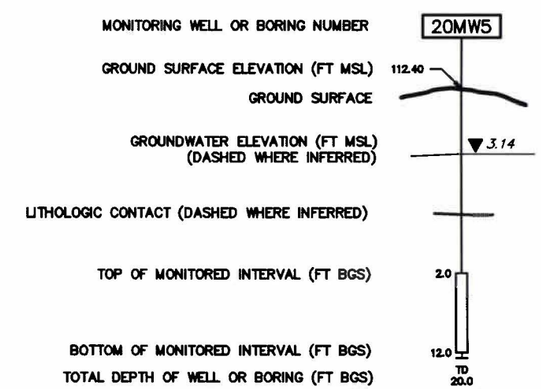

NOTES

1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)

2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997

DRAWN BY CK DATE 7/22/09	Tetra Tech NUS, Inc.	GENERALIZED ZONE 5 GEOLOGICAL CROSS SECTION LOWER SUBASE GROUNDWATER PRE-DESIGN INVESTIGATION NSB-NLON, GROTON, CONNECTICUT	CONTRACT NO. 2195
CHECKED BY DATE			OWNER NO. WE24
REVISED BY DATE			APPROVED BY CAR DATE 1/8/10
SCALE AS NOTED			DRAWING NO. FIGURE 10-6 REV. 0

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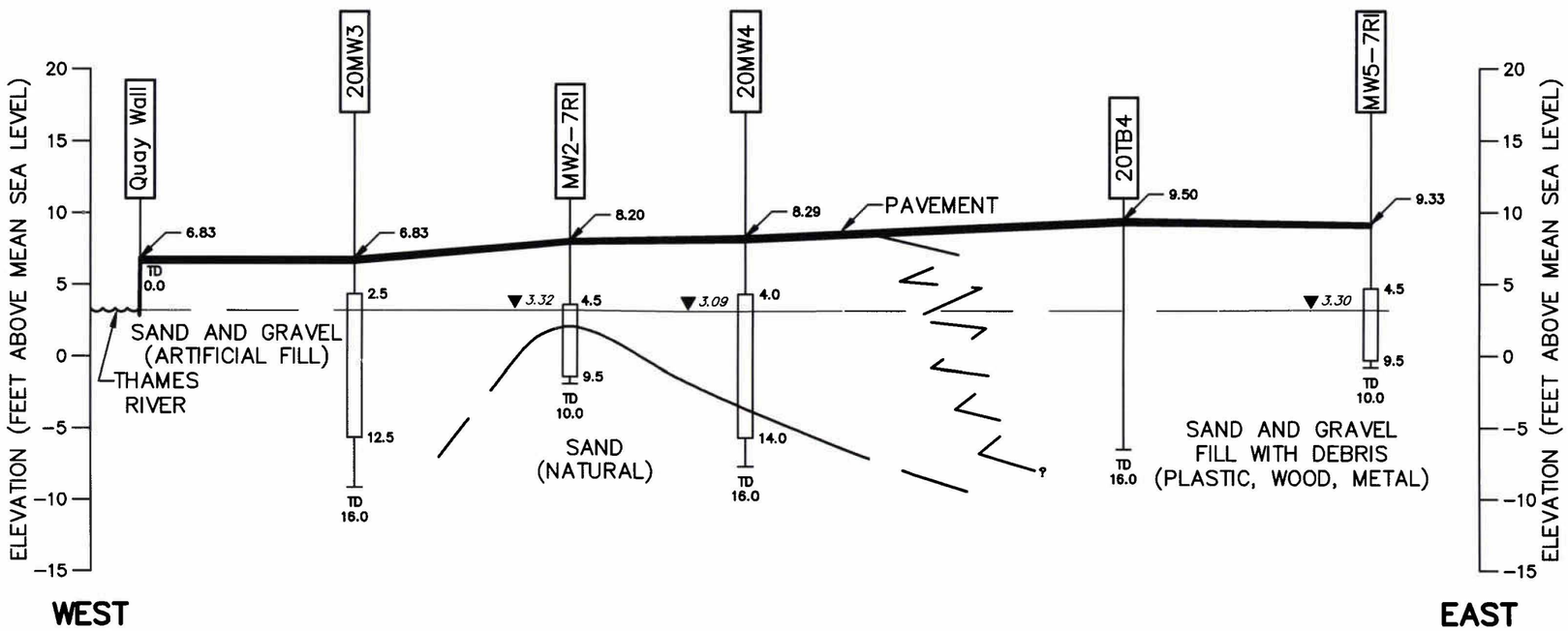

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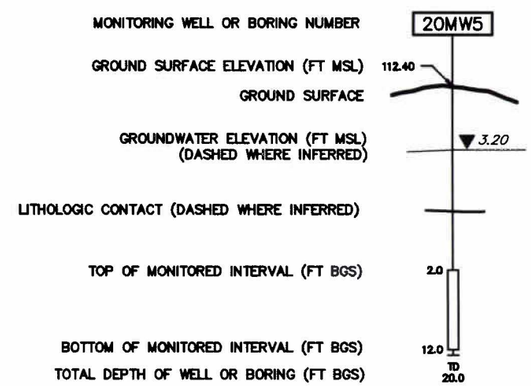
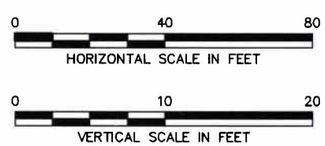


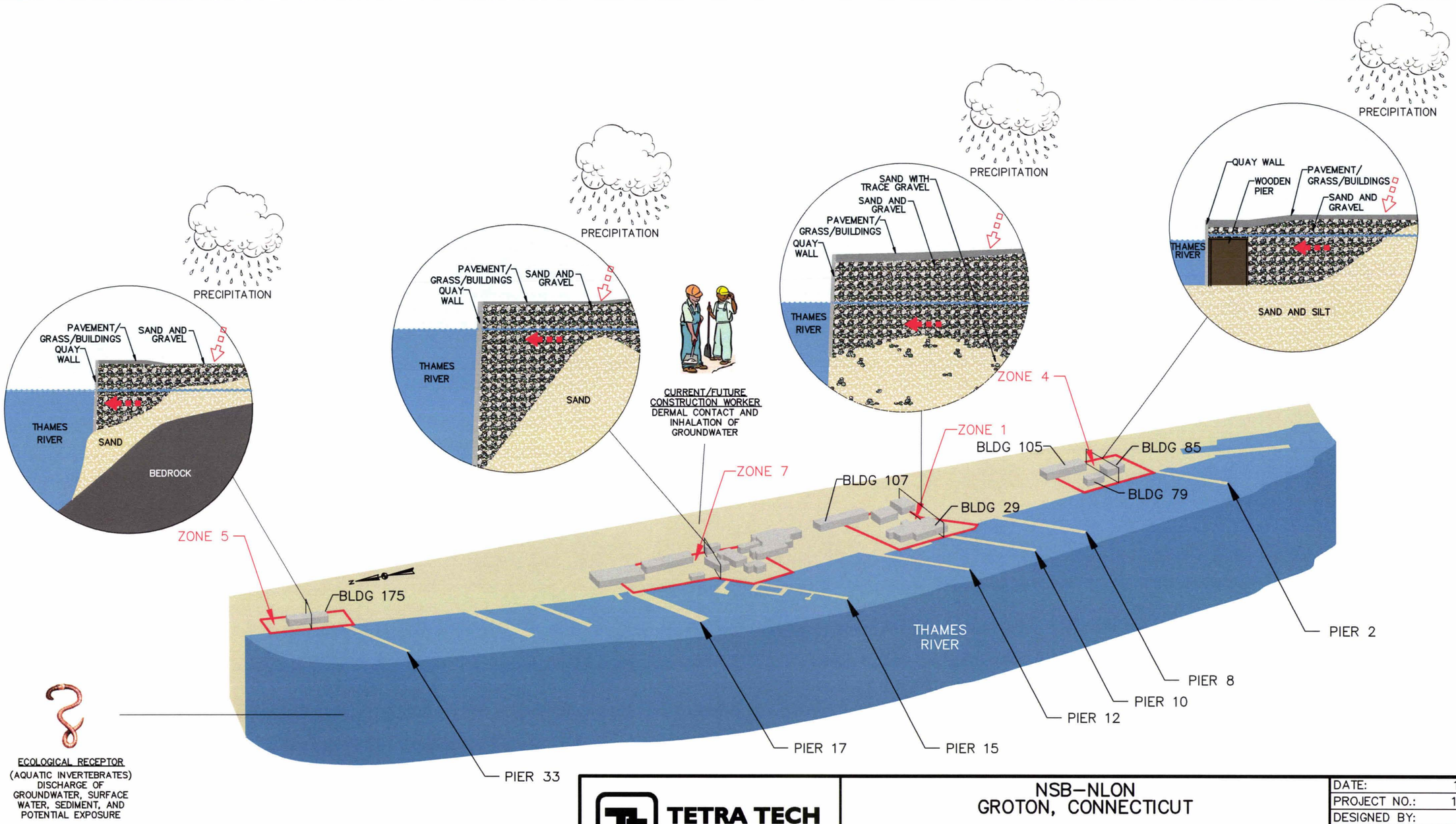


NOTES

1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)

2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997

DRAWN BY CK DATE 7/22/09	Tetra Tech NUS, Inc.	GENERALIZED ZONE 7 GEOLOGICAL CROSS SECTION LOWER SUBASE GROUNDWATER PRE-DESIGN INVESTIGATION NSB-NLON, GROTON, CONNECTICUT	CONTRACT NO. 2195
CHECKED BY DATE			OWNER NO. WE24
REVISED BY DATE			APPROVED BY CAR DATE 1/8/10
SCALE AS NOTED			DRAWING NO. FIGURE 10-7 REV. 0



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NSB–NLON
GROTON, CONNECTICUT

CONCEPTUAL SITE MODEL FOR GROUNDWATER

SCALE: NOT TO SCALE

DATE:	12–18–09
PROJECT NO.:	112G02195
DESIGNED BY:	
DRAWN BY:	CK
CHECKED BY:	CAR 1/8/10
SHEET:	OF ---

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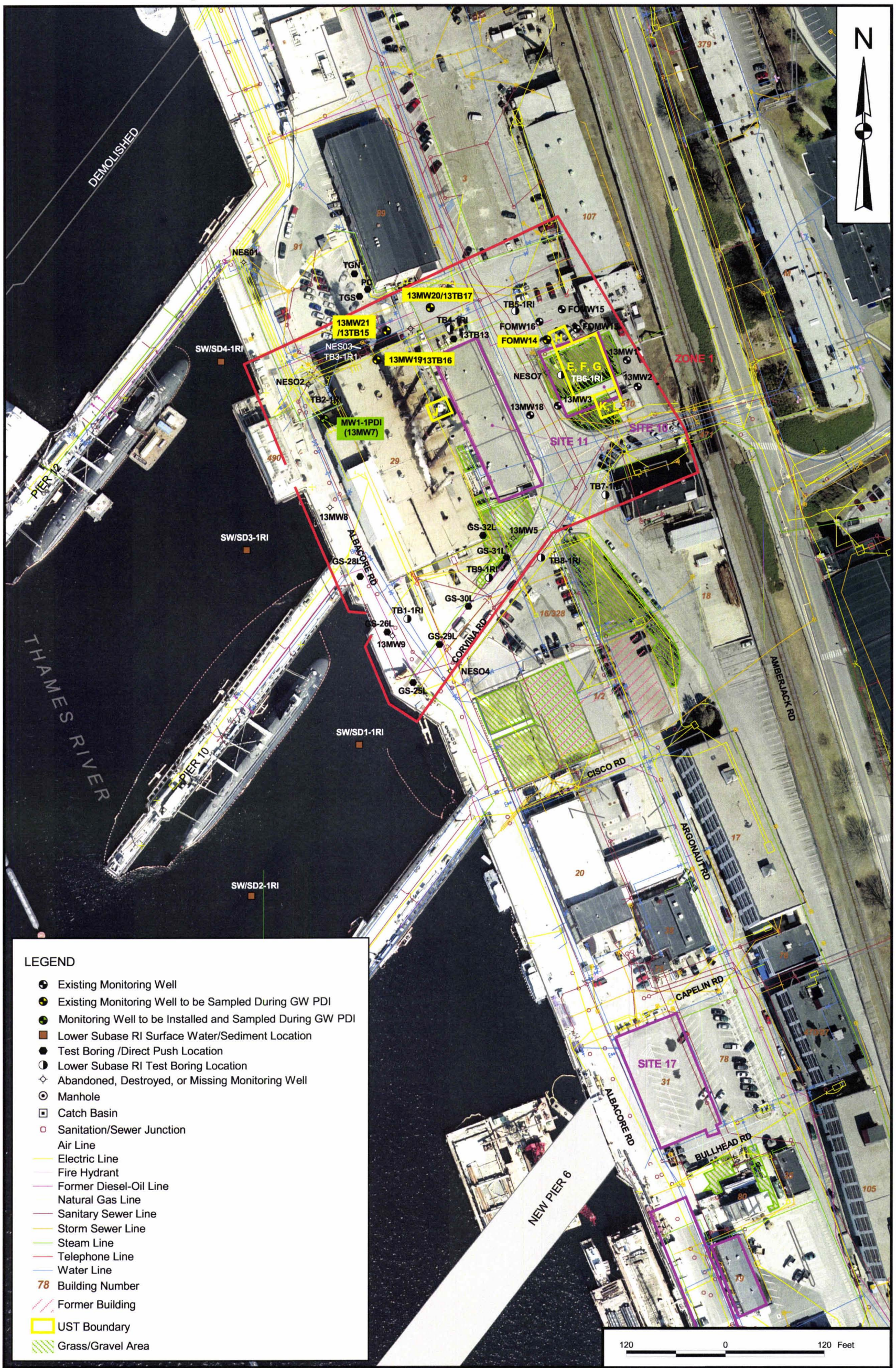
FIGURE 10–8

R:\2195\CSM\2195CSM01.dwg PIT CARLY.KRAMER 1/5/2010 2:06:30 PM

P:\GIS\NLON\MAPDOCS\SUBASE FEASIBILITY STUDY_ZONES.APR GW PDI ZONE 1 SAMPLE LOCATION LAYOUT 12/31/09 SS

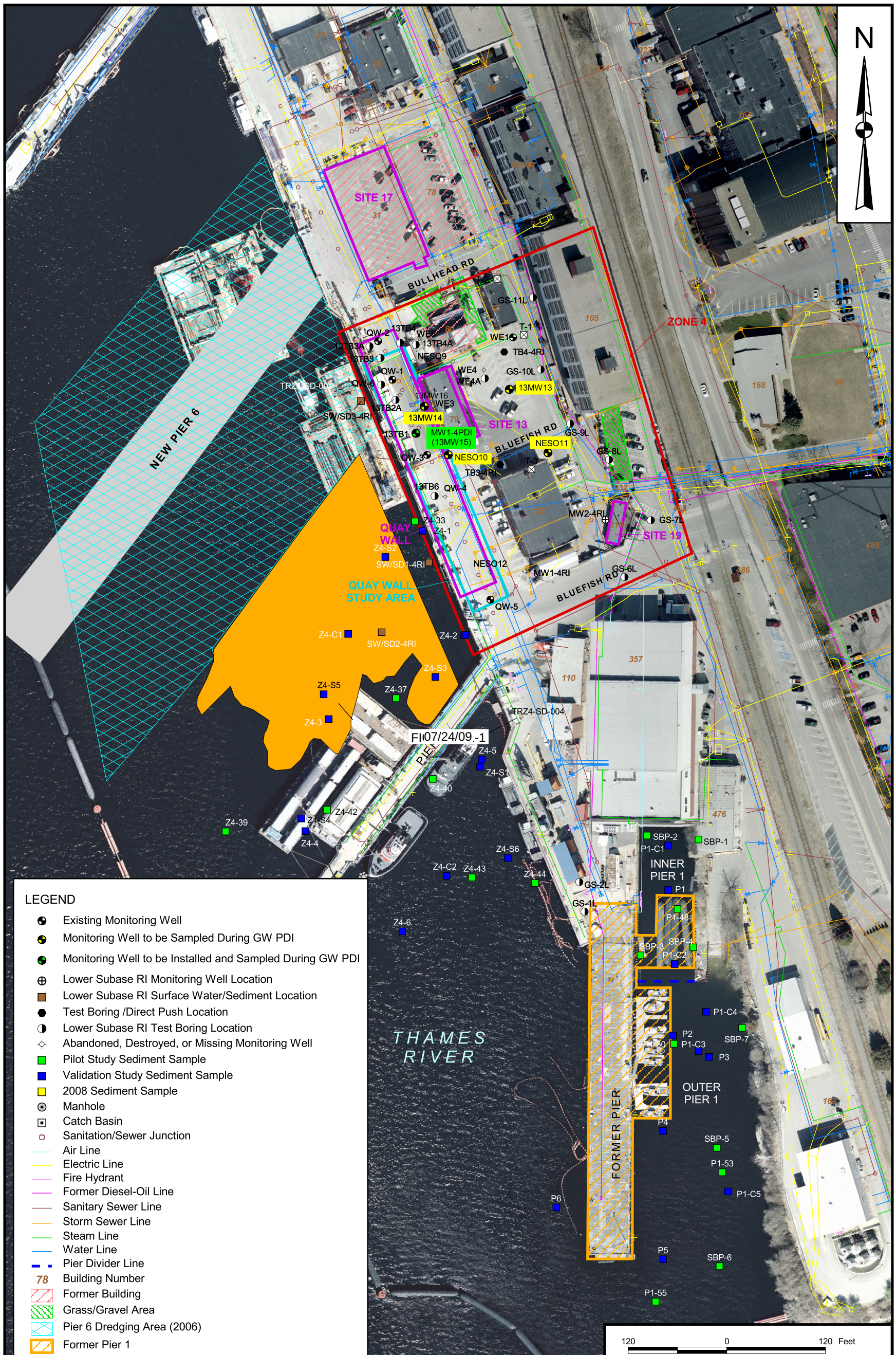


LEGEND

- Existing Monitoring Well
- Existing Monitoring Well to be Sampled During GW PDI
- Monitoring Well to be Installed and Sampled During GW PDI
- Lower Subase RI Surface Water/Sediment Location
- Test Boring /Direct Push Location
- Lower Subase RI Test Boring Location
- Abandoned, Destroyed, or Missing Monitoring Well
- Manhole
- Catch Basin
- Sanitation/Sewer Junction
- Air Line
- Electric Line
- Fire Hydrant
- Former Diesel-Oil Line
- Natural Gas Line
- Sanitary Sewer Line
- Storm Sewer Line
- Steam Line
- Telephone Line
- Water Line
- 78 Building Number
- Former Building
- UST Boundary
- Grass/Gravel Area

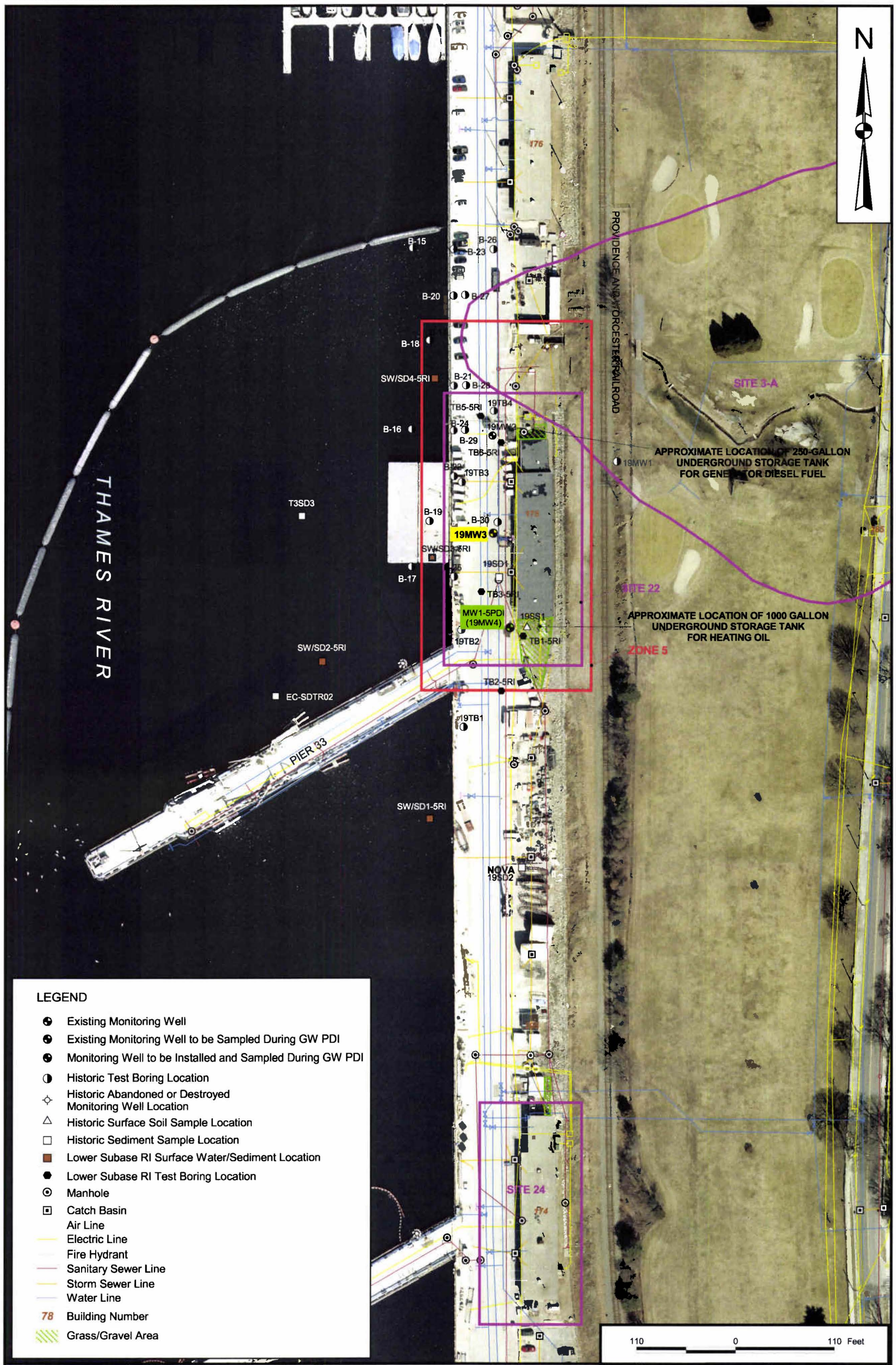
DRAWN BY S. STROZ DATE 12/30/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER
CHECKED BY C. RICH DATE 12/31/09	ZONE 1 SAMPLE LOCATION MAP LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR DATE 01/04/10	
COST/SCHEDULE-AREA		APPROVED CAR 07/24/09	
SCALE AS NOTED		DRAWING NO. FIGURE 11-1	REV 0

P:\GIS\NLON\MAPDOCS\SUBASE FEASIBILITY STUDY_ZONES.APR GW PDI ZONE 4 AND PIER 1 SAMPLE LOCATIONS LAYOUT 04/01/10 SS



DRAWN BY S. STROZ	DATE 11/05/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER
CHECKED BY G. STIEGEL	DATE 04/01/10	ZONE 4 SAMPLE LOCATION MAP LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR CAR	DATE 07/24/09 04/10
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 11-2	REV 0

P:\GIS\NLON\MAPDOCS\SUBASE FEASIBILITY STUDY_ZONES.APR GW PDI ZONE 5 SAMPLE LOCATIONS LAYOUT 12/31/09 SS



DRAWN BY S. STROZ — DATE 12/30/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER
CHECKED BY C. RICH — DATE 12/31/09	ZONE 5 SAMPLE LOCATION MAP LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR — DATE 01/04/10	
COST/SCHEDULE-AREA		APPROVED CAR — 07/24/09	
SCALE AS NOTED		DRAWING NO. FIGURE 11-3	REV 0

P:\GIS\NLON\MAPDOCS\SUBASE FEASIBILITY STUDY_ZONES.APR GW PDI ZONE 7 SAMPLE LOCATIONS LAYOUT 04/01/10 SS

DRAWN BY S. STROZ — DATE 12/30/09	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0424	OWNER NUMBER
CHECKED BY G. STIEGEL — DATE 04/01/10	ZONE 7 SAMPLE LOCATION MAP LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT	APPROVED BY CAR CAR — DATE 07/24/09	
COST/SCHEDULE-AREA		APPROVED BY — — DATE —	
SCALE AS NOTED		DRAWING NO. FIGURE 11-4	REV 0

APPENDIX A

FIELD STANDARD OPERATING PROCEDURES

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix
- Sorting of data by depth
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints (maximum of 20 characters)

2.0 SCOPE

The methods described in this SOP shall be used consistently for all projects requiring electronic data. Other contract- or project-specific sample nomenclature requirements may also be applicable.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Program Manager - It shall be the responsibility of the Project Manager (or designee) to inform contract-specific Project Managers (PMs) of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of the PM to determine the applicability of this SOP based on: (1) program-specific requirements and (2) project size and objectives. It shall be the responsibility of the PM (or designee) to ensure that sample nomenclature requirements are thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and are consistent with this SOP if relevant. It shall be the responsibility of the PM to ensure that the FOL is familiar with the sample nomenclature system.

Field Operations Leader (FOL) - It shall be the responsibility of the FOL to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP and the project-specific sample nomenclature system. It shall be the responsibility of the FOL to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

General personnel qualifications for sample nomenclature activities in the field include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for field documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 INTRODUCTION

The sample identification (ID) system can consist of as few as eight but not more than 20 distinct alpha-numeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the laboratory has three segments and shall be as follows, where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and sediment sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**NNNN 4 Characters**
Site identifier	Sample type	Sample location	Sample depth

(2) Aqueous (groundwater or surface water) sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**NN 2 Characters**	**-A 1 Character**
Site identifier	Sample type	Sample location	Round number	Filtered sample only

(3) Biota sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**AA 2 Characters**	**NNN 3 Characters**
Site identifier	Sample type	Sample location	Species identifier	Sample group number

5.2 SAMPLE IDENTIFICATION FIELD REQUIREMENTS

The various fields in the sample ID include but are not limited to the following:

- Site identifier
- Sample type
- Sample location
- Sample depth
- Sampling round number
- Filtered
- Species identifier
- Sample group number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary because many facilities/sites have multiple individual sites, Solid Waste Management Units (SWMUs), Operable Units (OUs), etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six characters (alpha, numeric, or a mixture). The six characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to three characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet or boring log, in the logbook, etc.

A two-digit round number will be used to track the number of aqueous samples collected from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three-digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001, and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 EXAMPLE SAMPLE FIELD DESIGNATIONS

Examples of each of the fields are as follows:

Site identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern (AOC) 1
125 - SWMU 125
000 - Base- or facility-wide sample (e.g., upgradient well)
BBG - Base background

The examples cited are only suggestions. Each PM (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample type - Examples of sample types are as follows:

AH - Ash Sample

AS - Air Sample
BM - Building Material Sample
BSB - Biota Sample Full Body
BSF - Biota Sample Fillet
CP - Composite Sample
CS - Chip Sample
DS - Drum Sample
DU - Dust Sample
FP - Free Product
IDW - Investigation-Derived Waste Sample
LT - Leachate Sample
MW - Monitoring Well Groundwater Sample
OF - Outfall Sample
RW - Residential Well Sample
SB - Soil Boring Sample
SD - Sediment Sample
SC - Scrape Sample
SG - Soil Gas Sample
SL - Sludge Sample
SP - Seep Sample
SS - Surface Soil Sample
ST - Storm Sewer Water Sample
SW - Surface Water Sample
TP - Test Pit Sample
TW - Temporary Well Sample
WC - Well Construction Material Sample
WP - Wipe Sample
WS - Waste/Solid Sample
WW - Wastewater Sample

Sample location - Examples of the location field are as follows:

001 - Monitoring well 1
N32E92 - Grid location 32 North and 92 East
D096 - Investigation-derived waste drum number 96

Species identifier - Examples of species identifier are as follows:

BC - Blue Crab
GB - Blue Gill
CO - Corn
SB - Soybean

5.4 EXAMPLES OF SAMPLE NOMENCLATURE

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full-body analysis, the first time a minnow trap was checked at grid location A25 of SWMU 1415, three small blue gills were captured, collected, and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415), the sample ID would be 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash (-F).

5.5 FIELD QA/QC SAMPLE NOMENCLATURE

Field Quality Assurance (QA)/Quality Control (QC) samples are designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC type	Date	Sequence number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
RB = Rinsate Blank (Equipment Blank)
FD = Field Duplicate
AB = Ambient Conditions Blank
WB = Source Water Blank

The sampling time recorded on the chain-of-custody form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log Sheet (see SOP SA-6.3, Field Documentation).

5.6 EXAMPLES OF FIELD QA/QC SAMPLE NOMENCLATURE

The first duplicate of the day for a filtered groundwater sample collected on June 3, 2000, would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003, would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000, would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001, would be designated as RB11170101.

6.0 DEVIATIONS

Any deviation from this SOP must be addressed in detail in the site-specific planning documents.

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1.0 PURPOSE

The purpose of this document is to specify a consistent procedure for the quality assurance review of electronic and hard copy databases. This SOP outlines the requirements for establishment of a Database Record File, Quality Assurance review procedures, and documentation of the Quality Assurance Review Process.

2.0 SCOPE

The methods described in this Standard Operating Procedure (SOP) shall be used consistently for all projects managed by Tetra Tech NUS (TtNUS).

3.0 GLOSSARY

Chain-of-Custody Form - A Chain-of-Custody Form is a printed form that accompanies a sample or a group of samples from the time of sample collection to the laboratory. The Chain-of-Custody Form is retained with the samples during transfer of samples from one custodian to another. The Chain-of-Custody Form is a controlled document that becomes part of the permanent project file. Chain-of-Custody and field documentation requirements are addressed in SOP SA-6.1.

Electronic Database - A database provided on a compact laser disk (CD). Such electronic databases will generally be prepared using public domain software such as DBase, RBase, Oracle, Visual FoxPro, Microsoft Access, Paradox, etc.

Hardcopy Database - A printed copy of a database prepared using the software discussed under the definition of an electronic database.

Form I - A printed copy of the analytical results for each sample.

Sample Tracking Summary - A printed record of sample information including the date the samples were collected, the number of samples collected, the sample matrix, the laboratory to which the samples were shipped, the associated analytical requirements for the samples, the date the analytical data were received from the laboratory, and the date that validation of the sample data was completed.

4.0 RESPONSIBILITIES

Database Records Custodian - It shall be the responsibility of the Database Records Custodian to update and file the Sample Tracking Summaries for all active projects on a weekly basis. It shall be the responsibility of the Database Records Custodian to ensure that the most recent copies of the Sample Tracking Summaries are placed in the Database Records file. It shall be the responsibility of the Database Records Custodian to ensure that a copy of all validation deliverables is provided to the Project Manager (for placement in the project file). It shall be the responsibility of the Database Records Custodian to ensure that photocopies of all validation deliverables and historical data and reports (as applicable) are placed in the Database Records file.

Data Validation Coordinator - It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that the Sample Tracking Summaries are maintained by the Database Records Custodian. It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that photocopies of all data validation deliverables are placed in the applicable Database Records file by the Database Records Custodian.

Earth Sciences Department Manager - It shall be the responsibility of the Earth Sciences Department Manager (or equivalent) to ensure that all field personnel are familiar with the requirements of this Standard Operating Procedure (specifically Section 5.5).

FOL - It shall be the responsibility of the FOL (FOL) of each project to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP, specifically regarding provision of the Chain-of-Custody Forms to the Database Records Custodian. Other responsibilities of the FOL are described in Sections 5.4 and 5.5.

Management Information Systems (MIS) Manager - It shall be the responsibility of the MIS Manager to ensure that copies of original electronic deliverables (CDs) are placed in both the project files and the Database Records File. It shall be the responsibility of the MIS Manager (or designee) to verify the completeness of the database (presence of all samples) in both electronic and hardcopy form in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that Quality Assurance Reviews are completed and are attested to by Quality Assurance Reviewers. It shall be the responsibility of the MIS Manager to ensure that records of the Quality Assurance review process are placed in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that both electronic and hardcopy forms of the final database are placed in both the project and the Database Record File. It shall be the responsibility of the MIS Manager to ensure that data validation qualifiers are entered in the database.

Furthermore, it shall be the responsibility of the MIS Manager to participate in project planning at the request of the Project Manager, specifically with respect to the generation of level of effort and schedule estimates. To support the project planning effort, the MIS Manager shall provide a copy of the MIS Request From included as Attachment A to the project manager. It shall be the responsibility of the MIS Manager to generate level of effort and budget estimates at the time database support is requested if a budget does not exist at the time of the request. The MIS Request Form shall be provided to the Project Manager at the time of any such requests. It shall be the responsibility of the MIS Manager to notify the Project Manager of any anticipated level of effort overruns or schedule noncompliances as soon as such problems arise along with full justification for any deviations from the budget estimates (provided they were generated by the MIS Manager). It shall be the responsibility of the MIS Manager to document any changes to the scope of work dictated by the Project Manager, along with an estimate of the impact of the change on the level of effort and the schedule.

Program/Department Managers - It shall be the responsibility of the Department and/or Program Managers (or designees) to inform their respective department's Project Managers of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of each Project Manager to determine the applicability of this SOP based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the FOL is familiar with the requirements regarding Chain-of-Custody Form provision to the Database Records Custodian. It shall be the responsibility of the Project Manager (or designee) to determine which, if any, historical data are relevant and to ensure that such data (including all relevant information such as originating entity, sample locations, sampling dates, etc.) are provided to the Database Records Custodian for inclusion in the Database Records File. It shall be the responsibility of the Project Manager to obtain project planning input regarding the level of effort and schedule from the MIS Manager. It shall be the responsibility of the Project Manager to complete the database checklist (Attachment A) to support the level of effort and schedule estimate and to facilitate database preparation and subroutine execution.

Risk Assessment Department Manager - It shall be the responsibility of the Risk Assessment Department Manager to monitor compliance with this Standard Operating Procedure, to modify this SOP as necessary, and to take corrective action if necessary. Monitoring of the process shall be completed on a quarterly basis.

Quality Assurance Reviewers - It shall be the responsibility of the Quality Assurance Reviewers to verify the completeness of the sample results via review of the Chain-of-Custody Forms and Sample Tracking Summaries. It shall be the responsibility of the Quality Assurance Reviewers to ensure the correctness of the database via direct comparison of the hardcopy printout of the database and the hardcopy summaries of the original analytical data (e.g., Form Is provided in data validation deliverables). Correctness includes the presence of all relevant sample information (all sample information fields), agreement of the laboratory and database analytical results, and the presence of data validation qualifiers.

Quality Manager - It shall be the responsibility of the Quality Manager to monitor compliance with this Standard Operating Procedure via routine audits.

5.0 PROCEDURES

5.1 Introduction

Verification of the accuracy and completeness of an electronic database can only be accomplished via comparison of a hardcopy of the database with hardcopy of all relevant sample information. The primary purposes of this SOP are to ensure that 1) all necessary hardcopy information is readily available to Quality Assurance Reviewers; 2) ensure that the Quality Assurance review is completed in a consistent and comprehensive manner, and; 3) ensure that documentation of the Quality Assurance review process is maintained in the project file.

5.2 File Establishment

A Database Record file shall be established for a specific project at the discretion of the Project Manager. Initiation of the filing procedure will commence upon receipt of the first set of Chain-of-Custody documents from a FOL or sampling technician. The Database Record Custodian shall establish a project-specific file for placement in the Database Record File. Each file in the Database Record File shall consist of standard components placed in the file as the project progresses. Each file shall be clearly labeled with the project number, which shall be placed on the front of the file drawer and on each and every hanging file folder relevant to the project. The following constitute the minimum components of a completed file:

- Electronic Deliverables
- Sample Tracking Forms
- Chain-of-Custody Forms
- Data Validation Letters
- Quality Assurance Records

5.3 Electronic Deliverables

The format of electronic deliverables shall be specified in the laboratory procurement specification and shall be provided by the laboratory. The integrity of all original electronic data deliverables shall be maintained. This shall be accomplished via the generation of copies of each electronic deliverable provided by the laboratory. The original electronic deliverable shall be provided to the project manager for inclusion in the project file. A copy of the original electronic deliverable shall be placed in the Database Record File. The second copy shall be maintained by the MIS Manager (or designee) to be used as a working copy.

5.4 Sample Tracking Forms

Updated versions of the sample tracking form for each relevant project shall be maintained by the Database Record Custodian. The Sample Tracking Forms shall be updated any time additional Chain-of-Custody Forms are received from a FOL or sampling technician, or at any time that data are received from a laboratory, or at any time that validation of a given data package (sample delivery group) is completed. The Data Validation Coordinator shall inform the Database Record Custodian of the receipt of any data packages from the laboratory and of completion of validation of a given data package to facilitate updating of the Sample Tracking Form. The Database Record Custodian shall place a revised copy of the Sample Tracking Form in the Database Record File anytime it has been updated. Copies of the updated Sample Tracking Form shall also be provided to the project manager to apprise the project manager of sample package receipt, completion of validation, etc.

5.5 Chain-of-Custody Forms

The Chain-of-Custody Forms for all sampling efforts will be used as the basis for (1) updating the Sample Tracking Form, and (2) confirming that all required samples and associated analyses have been completed. It shall be the responsibility of the FOL (or sample technician) to provide a photocopy of all Chain-of-Custody Forms to the Database Record Custodian immediately upon completion of a sampling effort. The Database Record Custodian shall then place the copies of the Chain-of-Custody Form(s) in the Database Record File. Upon receipt of a sample data package from an analytical laboratory, the Data Validation Coordinator shall provide a copy of the laboratory Chain-of-Custody Form to the Database Record Custodian. The Database Record Custodian shall use this copy to update the Sample Tracking Summary and shall place the copy of the laboratory-provided Chain-of-Custody Form in the Database Record File. The photocopy of the laboratory-provided Chain-of Custody Form shall be stapled to the previously filed field copy. Upon receipt of all analytical data, two copies of the Chain-of-Custody will therefore be in the file. Review of the Chain-of-Custody Forms will therefore be a simple mechanism to determine if all data have been received. Chain-of-Custody is addressed in SOP SA-6.1.

5.6 Data Validation Letters

All data validation deliverables (or raw data summaries if validation is not conducted) shall be provided for inclusion in both the Database Record File and the project file. If USEPA regional- or client-specific requirements are such that Form Is (or similar analytical results) need not be provided with the validation deliverable, copies of such results must be appended to the deliverable. It is preferable, although not essential that the validation qualifiers be hand-written directly on the data summary forms. The data validation deliverables (and attendant analytical summaries) will provide the basis for direct comparison of the database printout and the raw data and qualifiers.

5.7 Historical Data

At the direction of the Project Manager, historical data may also be included in a project-specific analytical database. In the event that historical data are germane to the project, hardcopy of the historical data must be included in the Database Record File. Historical data may be maintained in the form of final reports or as raw data. The information contained in the historical data file must be sufficient to identify its origin, its collection date, the sample location, the matrix, and any and all other pertinent information. All available analytical data, Chain-of-Custody Forms, boring logs, well construction logs, sample location maps, shall be photocopied by the Project Manager (or designee) and placed in one or more 3-ring binders. All information shall be organized chronologically by matrix. It shall be the responsibility of the Project Manager (or designee) to ensure that all inconsistencies between analytical data, Chain-of-Custody Forms, boring logs, sample log sheets, and field logbooks are identified and corrected. The Project Manager (or designee) shall decide which nomenclature is appropriate and edit, initial and date all relevant forms. Data entry may only be performed on information that has undergone the aforementioned

editing process, thereby having a direct correlation between hardcopy information and what will become the electronic database.

6.0 RECORDS

Records regarding database preparation and quality assurance review include all those identified in the previous section. Upon completion of the database task, records from the file will be forwarded to the Project Manager for inclusion in the project file, or will be placed in bankers boxes (or equivalent) for storage. The final records for storage shall include the following minimum information on placards placed on both the top and end of the storage box:

Database Record File
PROJECT NUMBER: ____
SITE NAME: _____
DATE FILED: __/__/__
SUMMARY OF CONTENTS ENCLOSED
BOX _ OF _

Project- or program-specific record keeping requirements shall take precedence over the record keeping requirements of this SOP.

ATTACHMENT A

MIS REQUEST FORM

Tetra Tech NUS, Inc.

Project Name:
CTO:
Project Manager:
Requestor:
Program/Client:
State/EPA Region:

Request Date:
Date Data Available for Production:
Request in Support of:
Database Lead:
GIS Lead:
Statistics Lead:
Risk Lead:

Site Name(s) (Area, OU, etc.):
Sampling Date(s):
Matrix: ☐ GW ☐ SO ☐ SD ☐ SW ☐ Other:

Labels: ☐ Labels needed for an upcoming sampling event _____ Total # of Samples
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
_____ FOL
Additional Instructions:

Data Entry:
☐ Chemical data needs to be entered from hardcopy _____ Estimated # of Samples
☐ Chemical data needs to be formated electronically
☐ Field analytical data needs to be entered from hardcopy
☐ Geologic data needs to be entered from hardcopy
☐ Hydrology data needs to be entered from hardcopy
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

Tables:
☐ Full Data Printout
☐ Summary of Positive Hits
☐ Occurance and Distribution ☐ with criteria
☐ Sampling Analytical Summary
☐ Other:
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

GIS:
☐ General Facility Location
☐ Site Location
☐ Potentiometric Contours/Groundwater Flow
☐ Sample Location Proposed
☐ Sample Location Existing
☐ Tag Map Single Round
☐ Tag Map Multiple Round
☐ Isoconcentrations
☐ Chart Map
☐ 3D Visualization
☐ EGIS CD
☐ Other:
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

Statistics: ☐ Yes
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

Geostatistics: ☐ Yes
_____ Estimated Hours
_____ Due Date
_____ Complete ETS Charge No.
Additional Instructions:

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1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate

previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.

2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):

   - Well number.
   - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
   - Time and day of the measurement.
   - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

ATTACHMENT A
MONITORING WELL INSPECTION SHEET

Monitoring Well Inspection Sheet

Project Name: _____ Date: _____

Location: _____ Time: _____

Tidally Influenced: Y / N Personnel: _____

Field Measurements				
Well ID	PID Reading PPM	Depth to Water *	Total Depth *	Flush Mt./ Stick-up

Well Construction Details (Taken from construction logs)		
Total Depth *	Ground Elev.	Top/Btm Screen *

Check List:

Riser Pipe Material:
Riser Notched for Surveyors:
Well ID Tag In-place:
Well security:
Photo taken:

Condition of Well:

Protective Case:
Riser:
Well Pad:
Other:

Presence/Evidence of:

Standing Water Around Well:
Existing Sampling Equipment:
Sediment build-up in Well Btm:

Comments:

** = Measurements are from the top of the inner case to the nearest 0.01'*

ATTACHMENT B
GROUNDWATER LEVEL MESUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ **Project No.:** _____
Location: _____ **Personnel:** _____
Weather Conditions: _____ **Measuring Device:** _____
Tidally Influenced: Yes ___ No ___ **Remarks:** _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Comments

* All measurements to the nearest 0.01 foot, from surveyed mark (unless noted)

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B COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION 12

1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained personnel may also serve in this capacity.

5.0 PROCEDURES

5.1 Equipment/Items Needed

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.
- Well drilling and installation equipment with associated materials (typically supplied by the driller).
- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).
- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

5.2 Well Design

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for trace contaminants.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

Casing Inside Diameter (Inch)	Standing Water Length to Obtain 1 Gallon Water (Feet)
2	6.13
4	1.53
6	0.68

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium- to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized id is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

5.3 Monitoring Well Installation

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to ensure proper placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly and their fall monitored closely to ensure that bridging does not occur.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for

installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for setting of the grout prior to drilling through the confined layer.

5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed.

5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials.

5.4 Well Development Methods

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development may yield information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to

remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen.

5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method.

5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular

space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

7.0 REFERENCES

Scalf, M. R., J. F. McNabb, W. J. Dunlap, R. L. Cosby, and J. Fryberger, 1981. Manual of Groundwater Sampling Procedures. R. S. Kerr Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Ada, Oklahoma.

Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

Driscoll, Fletcher G., 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota, 1989.

ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material						
	PVC 1	Galvanized Steel	Carbon Steel	Lo-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon*
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/ High Solids Content	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

1 Teflon®
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

Potentially-Deteriorating Substance	Type of Casing Material								
	PVC Flexible	PP	PE Conv.	PE Linear	PMM	Viton®*	Silicone	Neoprene	Teflon®*
Buffered Weak Acid	97	97	100	97	90	92	87	85	100
Weak Acid	92	90	94	96	78	78	75	75	100
Mineral Acid/ High Solids Content	100	100	100	100	95	100	78	82	100
Aqueous/Organic Mixtures	62	71	40	60	49	78	49	44	100
Percent Overall Rating	88	90	84	88	78	87	72	72	100

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

1 Teflon®
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton®
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

Characteristic	Stainless Steel	PVC
Strength	Use in deep wells to prevent compression and closing of screen/riser.	Use when shear and compressive strength are not critical.
Weight	Relatively heavier.	Light-weight; floats in water.
Cost	Relatively expensive.	Relatively inexpensive.
Corrosivity	Deteriorates more rapidly in corrosive water.	Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons.
Ease of Use	Difficult to adjust size or length in the field.	Easy to handle and work with in the field.
Preparation for Use	Should be steam cleaned if organics will be subsequently sampled.	Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells.
Interaction with Contaminants*	May sorb organic or inorganic substances when oxidized.	May sorb or release organic substances.

* See also Attachment A.

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1.0 PURPOSE

Well abandonment is that procedure by which any monitoring well is permanently closed. Abandonment procedures are designed to prevent fluids from entering or migrating within the monitoring well. Therefore, an abandoned monitoring well must be sealed in such a manner that it can not act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers.

It is important that the appropriate state or local agency be notified of monitoring well abandonment. The application of and adherence to this SOP must be tailored to applicable state, local, and Federal regulatory requirements.

2.0 SCOPE

The methods described in this procedure shall be used for all projects requiring well abandonment where specific state, local, or Federal regulations are unavailable. An abandoned well shall be filled and sealed so that it will not act as a pathway for the interchange of water between the surface and subsurface or present a hazard to the environment.

3.0 GLOSSARY

Well - Any constructed access point to an aquifer, confined or unconfined, including, but not limited to, test borings, hydropunch holes, monitoring points, and production wells.

Abandon - To permanently discontinue the use of a well. Any well shall require abandonment when it is no longer serving as a monitoring point or is in such a state of disrepair that continued use for the purpose of obtaining groundwater is impracticable, or when it has been permanently disconnected from any water supply system or irrigation system.

4.0 RESPONSIBILITIES

Project Manager - It shall be the responsibility of the Project Manager and/or Project Hydrogeologist to determine the applicability of well abandonment, based on the established scope and objective of the project and program-specific requirements. It shall be the responsibility of the Project Manager (or designee) to ensure that the procedures established for well abandonment are thoroughly specified and/or referenced in the relevant project planning documents. It shall be the responsibility of the Project Manager to ensure that the Field Operations Leader is familiar with the proper procedures for well abandonment and confirm the supervising project geologist or the subcontractor performing the well abandonment are qualified to perform such activities.

Field Operations Leader (FOL) - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians and/or drilling personnel are thoroughly familiar with this Standard Operating Procedure. It shall be the responsibility of the FOL to ensure that the procedures identified in this SOP are used during well abandonment.

5.0 PROCEDURES

5.1 General

Well abandonment is warranted when the project team has reason to believe, on the basis of local conditions, that the well is causing or is a potential source of pollution to an aquifer; is a production well that is producing water that is polluted; or does not have a certificate of potability, if required. Wells may

also be abandoned once their designed purposes have been fulfilled and are determined to no longer be of use.

Well abandonment is conducted to eliminate physical hazards, prevent groundwater contamination, prevent intermixing of aquifer waters, and conserve aquifer yield and hydrostatic head.

Please note Federal, state, and local regulations concerning this activity may vary. Therefore, applicable regulatory requirements should be reviewed to determine the need for Licensed/Certified Well Drillers to complete/oversight this activity.

5.2 Material for Sealing

Acceptable sealing materials include concrete, portland cement grout, sodium-base bentonite clay, or combinations of these materials. These materials are defined as follows:

- Concrete may be used for filling the upper part of a well or water bearing formation, or plugging short sections of casing and filling large diameter wells.

- Portland cement grout is superior for sealing small openings, penetrating any annular space outside the casing, and for filling voids in the surrounding formation. Portland cement grout shall be composed of one bag of Type I cement per 6 to 8 gallons of water. Two parts sand to one part cement may be added.

- Bentonite clay, when applied as a heavy mud-laden fluid under pressure, has most of the advantages of cement grout, but under some conditions may be carried away into the surrounding formation. A bentonite clay mixture shall be composed of not less than 2 pounds of clay per gallon of water. Bentonite clay may not be used where it will come in contact with water of a pH below 5.0 or total dissolved solids (TDS) content greater than 1,000 mg/L or both. Bentonite may also be added to cement grout to add flexibility.

Fill materials include clay, silt, sand, gravel, crushed stone, or a mixtures of these materials may be used as a filler in sealing a well when used in conjunction with the sealing materials described above. Organic material may not be used and fill material may be required to be disinfected or certified clean prior to use. Spent drilling muds or drill cuttings are not to be used to seal a well.

5.3 Procedures for Sealing Wells

5.3.1 Preliminary Considerations

Several factors should be considered to determine the appropriate well abandonment method. These factors include:

- Conditions of the well.
- Details of well construction, including casing material, diameter of casing, depth of well, and well plumbness.
- Obstructions within the well that may interfere with filling or sealing.
- Hydrogeologic setting.
- Level of contamination and the zone or zones where it occurs.
- Regulatory requirements.

Degraded wells may not permit casing removal by pulling. Also, the casing material may dictate whether a casing can be removed intact. Stainless steel will have a higher tensile strength than PVC and may hold

together while pulling the casing; PVC well casing may break under pulling and may need to be overdrilled to remove it. The depth of the well and well plumbness may limit casing removal depending on whether a casing is pulled or overdrilled. In some cases, casings can be left in-place if they are properly filled with appropriate backfill.

The formation lithology influences the selection of casing removal. Unconsolidated materials can be drilled with hollow-stem augering techniques whereas consolidated materials cannot. Unconsolidated materials may also cave-in during well casing removal.

5.3.2 Filling and Sealing Procedures

Drilled wells (all wells not dug) shall be filled with sealing material or a combination of sealing material and fill material.

In some cases, well casing removal is necessary for well abandonment. If the borehole is unstable and may cave-in, sealing material will be emplaced simultaneously during casing removal. If the well is not grouted, casing may be pulled with hydraulic jacks or a drilling rig. It may also be pulled by sandlocking. Sandlocking consists of lowering a pipe wrapped with burlap approximately 2/3 of the well depth and filling the burlap wrap with sand. The pipe is slowly lifted and locks the sand, pulling the casing. Well casings can also be removed by overdrilling. Wells can be overdrilled with larger diameter hollow steam or solid stem augers or direct rotary techniques, using air or mud. Augers used for overdrilling should be at least 2 inches larger in diameter than the diameter of the well casing.

If well casing is in poor condition or is grouted in place, the casing may be ripped or perforated and filled and pressure grouted in place.

Abandoned wells shall be filled with the appropriate filling and sealing material placed from the bottom of the well upward. When Portland cement grout or concrete is used, it shall be placed in continuous operation using a tremie pipe. Sealing material shall be placed in the interval or intervals to be sealed by methods that prevent free fall, dilution, and/or separation of aggregates from cementing material.

A well constructed in unconsolidated material in an unconfined groundwater zone shall be filled and sealed by placing fill material in the well to the level of the water table, and filling the remainder of the well with sealing material. If the water table is at a depth greater than 40 feet, a minimum of 40 feet of sealing material shall be required.

A well which penetrates several aquifers or formations shall be filled and sealed in such a way as to prevent the vertical movement of water from one aquifer or formation to another. If the casing has been removed, sealing material shall be placed opposite the confining formations and from the surface down to the first confining formation. Sand and other suitable fill material may be placed opposite the producing aquifer. Ideally, the entire well can be filled with sealing material. If the casing has not been removed, the entire well shall be fill with sealing material.

A well penetrating creviced or cavernous rock shall be filled using coarse fill material opposite the cavernous or creviced rock portions of the well. Sealing material shall extend from the top of the unfractured rock portion of the well or base of the casing, whichever is deeper, to the surface. The minimum depth of sealing material may not be less than 10 feet.

In the case where wells penetrate specific aquifers where conditions necessitate the sealing of specific aquifers or formations, the annular space in the area of the specific aquifer or formation shall be sealed during the abandonment of the well.

A dug well exceeding 24 inches in diameter shall be filled and sealed by placing fill material (excluding clay or silt) in the well to a level approximately 5 feet below the land surface, and placing a 3 foot plug of sealing material above the fill. The remainder of the well shall be back filled with soil material.

6.0 REFERENCES

Maryland Department of the Environment (MDE Regulations); Title 26, Subtitle 04; Regulation of Water Supply, Sewage Disposal, and Solid Waste; Chapter 4--Well Construction.

U.S. EPA, February 1990. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.

TETRA TECH	STANDARD OPERATING PROCEDURES	Number SA-1.1	Page 1 of 34
		Effective Date 04/07/2008	Revision 7
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING		Approved Tom Johnston	

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 microSiemens per centimeter (mS/cm) at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Groundwater Sample – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 mV from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCl) in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCl) to 205 (3.5 Molar KCl) to 222 mV (1 Molar KCl) at 25°C and are greater at lower temperatures.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol ($^0/_{00}$) is not the same as the percent symbol (%).

Turbidity – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Project Hydrogeologist – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

Field Operations Leader (FOL) – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.
General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas and roadways and along highways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations – To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.

- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.

- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.

- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.

- **Provide a required free space of travel.** Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.

- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.

- Wear high-visibility vests to increase visual recognition by motorists.

- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.

- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 General

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample. To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

CAUTION

Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

1. If possible, position yourself (and the sampling equipment) upwind of the well head.

2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.

3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid (generally 300 mL per minute or greater), attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

CAUTION

For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:

   - Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.

   - While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

- Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform to the guidelines in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.
- Field tools and instrumentation
  - Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable)
  - pH Paper
  - Camera and film (if appropriate)
  - Appropriate keys (for locked wells)
  - Water level indicator and/or oil-water interface probe if separate-phase product is expected
- Pumps
  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.
  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.
- Other sampling equipment – Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).
- Pails – Plastic, graduated.
- Clean paper or cotton towels for cleaning equipment.
- Buckets with lids for collecting purge water.
- Decontamination solutions – Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

6.3 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

1. Obtain all available information on well construction (location, casing, screen, etc.).

2. Determine well or inner casing diameter.

3. Measure and record static water level (depth below ground level or top of casing reference point).

4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.

5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

   where: V = Static volume of well in gallons.
   T = Linear feet of water in the well.
   r = Inside radius of well casing in inches.
   0.163 = Conversion factor (compensates for conversion of casing radius from inches to feet and cubic feet to gallons and pi.

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

1. Saturate a paper towel or clean cotton towel with deionized water.

2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.

3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Material Safety Data Sheet (MSDS) is obtained, kept on site at a readily available location with other MSDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the TtNUS Health and Safety Guidance Manual [HSGM], Hazard Communication Program and OSHA Standard 29 CFR 1910.1200).

6.4 Evacuation of Static Water – Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom. Bailers are comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

Advantages of bailers include the following:

- There are few limitations on size and materials used.
- No external power source is needed.
- Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.
- Splashing the bailer into the water or transfer of sample may cause aeration.
- The use of a bailer does not permit constant in-line monitoring of groundwater parameters.
- Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.

Safety concerns using a bailer include the following:

- Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.
- Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.
- Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.

Control measures for these hazards are provided in Section 6.6.2.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it will operate from a portable battery source. Safety measures associated with these pumps are provided below.

Air-Lift and Gas-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.

- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time consuming.

Compressed Gases

Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 psi. If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through an appropriate pressure-reducing regulator.
- When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.
- If the cylinder is designed to accept a valve protection cap, always keep that protection cap in place, except the cylinder is connected for use.
- When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).
- DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential danger of an embolism.

See the project-specific HASP for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of a running car to access the battery as a power source. To control these hazards:

- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.
- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the HSGM.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ORP
- Turbidity
- Salinity

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters

used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

6.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.
- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 Code of Federal Regulations (CFR) 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain MSDSs from the manufacturer for the specific buffer solutions (see Section 4 of the HSGM regarding the Hazard Communication Program)

- pH indicator paper to cover the pH range 2 through 12.
- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

1. Inspect the instrument and batteries prior to initiation of the field effort.
2. Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.
3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).
4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.
5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.
6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).
7. Rinse the electrode(s) with deionized water.
8. Store the electrode(s) in an accordance with manufacturer's instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

1. Collect a small portion of sample into a clean container.

2. Dip the pH paper into this small portion of sample.

3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.

4. Record the pH value from the chart on the sampling log sheet.

5. Discard the used pH paper as trash.

6. Discard the small volume of sample that was used for the pH measurement with the other investigative derived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form.

6.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.
4. Immerse the electrode in the sample and measure the conductivity.
5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.

2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

1. Calibrate the instrument according to manufacturer's recommendations prior to use.

2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.

3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 Principles of Equipment Operation

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between

the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

1. Check the DO meter batteries before going to the field.
2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
5. Rinse the probe with deionized water.
6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.

7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.

8. Rinse the probe with deionized water.

9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.

2. Thoroughly rinse the electrode with deionized water.

3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.

4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater). Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).
- Calibration solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.

2. Check batteries and calibrate the meter before going into the field.

3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.

5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.

6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (e.g., LaMotte 2020) that calibrates easily using test cells with standards of 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

- Calibration solution and sample tubes, as specified by the manufacturer.

- Manufacturer's operation manual.

6.5.7.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization shall be done according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
2. Check batteries and calibrate the instrument before going into the field.
3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.
4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.
5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, and close the lid.
6. Immerse the electrode in the sample and measure the turbidity.
7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.
8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.
9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- Background and objectives of sampling.
- Brief description of area and waste characterization.
- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).
- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated.

Refer to the project-specific HASP for appropriate information and direction on air monitoring requirements.

- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.
- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP, indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP author.
- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow. Where sampling teams are made up of personnel from multiple locations, personal sampling experiences may vary. Therefore the FOL shall review project-specific requirements, SOPs, and protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are being completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like to sun themselves on concrete well pads. Follow provisions in the project-specific HASP and/or HSGM for addressing natural hazards.

2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases form contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:

   - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.
   - DO NOT place your face or any other part of your body over the well when opening because this may place you in a strike zone.
   - Open the well cover at arms length, then step away and allow the well to off gas and stabilize.

   Follow directions provided in the project-specific HASP, Work Plan and/or Sampling Plan pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the sampler

during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP).

3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.

4. Calculate volume of well water to be removed as described in Section 6.3.

5. Select the appropriate purging equipment (see Attachment A to this SOP) or as designated within your Work Plan/Sampling Plan. If an electric submersible pump with packer is chosen, go to Step 10.

6. Lower the purging equipment or intake into the well to a short distance below the water level or mid-screen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water was as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.

7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.

8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

9. Purge a minimum of three to five casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.

10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record this

occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.

14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.

15. Process sample containers as described in SOP SA-6.1.

16. Decontaminate equipment as described in SOP SA-7.1.

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, polychlorinated biphenyls [PCBs], metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).

- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.

- Tubing – Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.

- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).

- Interface probe.
- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators - ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic compounds (VOCs) per the HASP.

6.7.3 Purging and Sampling Procedure

1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP (typically with a PID or FID).

2 Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.

3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.

4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well

5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.

6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease or the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.

7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.

9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.

10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.

11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:

    - pH ±0.2 standard units
    - Specific conductance ±10%
    - Temperature ±10%
    - Turbidity less than 10 NTUs
    - DO ±10%

12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.

NOTE: VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:

- Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.
- Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.
- Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.
- Prepare samples for shipping as per SOP SA-6.1.

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015-20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$1,200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/18	PVC, nylon	0-1,100	250 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	0-330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

- PE Polyethylene
- PP Polypropylene
- PVC Polyvinyl chloride
- SS Stainless steel
- PC Polycarbonate
- EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

- NA Not applicable
- AC Alternating current
- DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: _____
[ ] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
Method:								

PURGE DATA

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS/NOTES

QA/QC APPLICATION

NS/MSD	Duplicate ID No.:	Signature(s):

ATTACHMENT C
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT D
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____ **WELL ID.:** _____
PROJECT NUMBER: _____ **DATE:** _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): _____ **PAGE___OF___**

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (~~y~~261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (~~y~~261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration			Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER						
Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[9]
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO_3 to pH ≤2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days
SOIL						
Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR						
Volatile Organics	Low/Medium		Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH 2; H_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] HCl to pH 2 [9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5 [10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Benzidines[11], [12]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11], [14]	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PCBs[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs)[11],[14]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
(5) Should only be used in the presence of residual chlorine.
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
(7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting Tetra Tech NUS, Inc. (TtNUS) field activities.

2.0 SCOPE

Documents presented within this SOP (or equivalents) shall be used for all TtNUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager (PM) - The PM is responsible for obtaining hardbound controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The FOL is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports included in this SOP (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time frame.

General personnel qualifications for field documentation activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 SITE LOGBOOK

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, record or reference the following activities/events (daily) in the site logbook:

- All field personnel present
- Arrival/departure times and names of site visitors
- Times and dates of health and safety training
- Arrival/departure times of equipment
- Times and dates of equipment calibration

- Start and/or completion of borehole, trench, monitoring well installation activities, etc.
- Daily on-site activities
- Sample pickup information
- Health and safety issues (level of protection, personal protective equipment [PPE], etc.)
- Weather conditions

Maintain a site logbook for each project and initiate it at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Make entries every day that on-site activities take place involving TtNUS or subcontractor personnel. Upon completion of the fieldwork, provide the site logbook to the PM or designee for inclusion in the project's central file.

Record the following information on the cover of each site logbook:

- Project name
- TtNUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, either record the measurements and equipment used in the site logbook or reference the field notebook in which the measurements are recorded (see Attachment A).

Make all logbook, notebook, and log sheet entries in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, cross out the entry with a single strike mark, initial, and date it. At the completion of entries by any individual, the logbook pages used must be signed and dated by the person making the entries. The site logbook must also be signed by the FOL at the end of each day.

5.1.2 Photographs

Sequentially number movies, slides, or photographs taken of a site or any monitoring location to correspond to logbook/notebook entries. Enter the name of the photographer, date, time, site location, site description, and weather conditions in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided because they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend on the subject matter, type of camera (digital or film), and the processing it requires. Follow chain-of-custody procedures for film used for aerial photography, confidential information, or criminal investigation. After processed, consecutively number the slides of photographic prints and label them according to the logbook/notebook descriptions. Docket the site photographs and associated negatives and/or digitally saved images to compact disks into the project's central file.

5.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a

separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 FIELD FORMS

All TtNUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs, subject to client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOPs.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample log sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. Complete a sample log sheet for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Complete the required information on the adhesive labels and apply them to every sample container. Obtain sample labels from the appropriate program/project source, request that they be electronically generated in house, or request them the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record

The chain-of-custody record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used as follows for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site:

- Retain one carbonless copy of the completed chain-of custody form in the field.
- Send one copy is sent to the PM (or designee)
- Send the original to the laboratory with the associated samples. Place the original (top, signed copy) of the chain-of custody form inside a large Ziploc®-type bag taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one chain-of custody form, send the form with the cooler containing vials for volatile organic compound (VOC) analysis or the cooler with the air bill attached. Indicate on the air bill how many coolers are included with that shipment.

An example of a chain-of-custody form is provided as Attachment C. After the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed chain-of custody form (any discrepancies between the sample labels and chain-of custody form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the TtNUS PM). The chain-of custody form is signed and copied. The laboratory will retain the copy, and the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label that is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. Sign and date custody seals

and affix them across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). Obtain custody seals from the laboratory (if available) or purchase them from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Complete Field Analytical Log Sheets to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

Complete a Groundwater Level Measurement Sheet for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. Use a Pumping Test Data Sheet to facilitate this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be established in advance.

5.3.2.3 Packer Test Report Form

Complete a Packer Test Report Form for each well at which a packer test is conducted.

5.3.2.4 Boring Log

Complete a Summary Log of Boring, or Boring Log for each soil boring performed to document the materials encountered, operation and driving of casing, and locations/depths of samples collected. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a photoionization detector [PID] or flame ionization detector [FID]), enter these readings on the boring log at the appropriate depth. When they become available, enter the laboratory sample number, concentrations of key contaminants, or other pertinent information in the "Remarks" column. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

Complete a Monitoring Well Construction Details Form for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Miscellaneous monitoring well forms that may be required on a project-specific basis include the Monitoring Well Materials Certificate of Conformance and Monitoring Well Development Record. Use a Monitoring Well Materials Certificate of Conformance to document all materials utilized during each monitoring well installation. Use a Monitoring Well Development Record to document all well development activities.

5.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Miscellaneous field forms/checklists forms that may be required on a project-specific basis include the following:

- Container Sample and Inspection Sheet – use this form when a container (drum, tank, etc.) is sampled and/or inspected.
- QA Sample Log Sheet – use this form when a QA sample such as an equipment rinsate blank, source blank, etc. is collected.
- Field Task Modification Request (FTMR) – use this form to document deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Maintain copies of all FTMRs with the on-site planning documents, and place originals in the final evidence file.
- Field Project Daily Activities Checklist and Field Project Pre-Mobilization Checklist – used these during both the planning and field effort to ensure that all necessary tasks are planned for and completed. These two forms are not requirements but are useful tools for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure the proper operation and response of the equipment, to document the accuracy, precision, or sensitivity of the measurements, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log, which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. Maintain an Equipment Calibration Log for each electronic measuring device used in the field; make entries for each day the equipment is used or in accordance with manufacturer recommendations.

5.4 FIELD REPORTS

The primary means of recording on-site activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation but are not easily used for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain on site for extended periods of time and are thus not accessible for timely review by project management. Other reports useful for tracking and reporting the progress of field activities are described below.

5.4.1 Daily Activities Report

To provide timely oversight of on-site contractors, complete and submit Daily Activities Reports (DARs) as described below.

5.4.1.1 Description

The DAR documents the activities and progress for each day's field work. Complete this report on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring that involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the DAR to the FOL for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DARs are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the PM.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

In addition to those described herein, other summary reports may also be contractually required.

All TtNUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF FIELD FORMS ON THE TtNUS INTRANET SITE

- Boring Log
- Container Sample and Inspection Sheet
- Daily Activities Checklist
- Daily Activities Record
- Equipment Calibration Log
- Field Task Modification Request
- Field Analytical Log sheet - Geochemical Parameters
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Hydraulic Conductivity Test Data Sheet
- Low Flow Purge Data Sheet
- Bedrock Monitoring Well Construction (Stick Up)
- Bedrock Monitoring Well Construction Flush Mount
- Bedrock Monitoring Well Construction Open Hole
- Confining Layer Monitoring Well Construction
- Monitoring Well Development Record

- Monitoring Well Materials Certificate of Conformance
- Overburden Monitoring Well Construction Flush Mount
- Overburden Monitoring Well Construction Stick Up
- Packer Test Report Form
- Pumping Test Data Sheet
- QA Sample Log Sheet
- Soil/Sediment Sample Log Sheet
- Surface Water Sample Log Sheet
- Test Pit Log
- Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B
SAMPLE LABEL

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:		
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:	Laboratory:		

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER 3413 | PAGE ____ OF _____

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS										COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date	**Date**
Signature	**Signature**

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A INVESTIGATION-DERIVED WASTE LABEL 15

1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment , chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities

- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:

  - Well removed from pedestrian/vehicle thoroughfares.

  - Avoidance of areas where control/custody cannot be maintained.

  - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.

  - Avoidance of potentially contaminated areas.

  - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

  The selected decontamination site should include the following, where possible:

  - Areas where potable water and electricity are provided.

> ***Safety Reminder***
>
> When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:
>
> - All power is routed through a Ground Fault Circuit Interrupter (GFCI).
>
> - All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.
>
> In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.

- Areas that offer sufficient size to carry out the specific decontamination sequence.

- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.

  - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.

  - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.

  - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.

  - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:

  - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

- Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.

- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.

2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.

3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.

4. Remove the pump and tubing/bailer from the container

5. Rinse external pump components using tap water.

6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents –
> Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.

8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.

9. Drain residual deionized water to the extent possible.

10. Allow components of the equipment to air dry.

11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.

12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

> ***SAFETY REMINDER***
> Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

> ***NOTE***
> In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.

- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:

  1. Wash with soap and water
  2. Rinse with tap water
  3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

> ***CAUTION***
> Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

> ***CAUTION***
> In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol

5. To the extent possible, allow components to air dry.

6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.

7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 ˚F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0˚ tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40˚ fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.

2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.

3. Always wear PPE as specified in the HASP such as:

   - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.

4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.

5. Do not modify equipment unless the manufacturer has approved the modifications.

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.

3. Rinse the equipment with tap water.

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.

5. Rinse the equipment with deionized water.

6. To the extent possible, allow components to air dry.

7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.

8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device

- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.

- Extract the dredge and wash it in soap and water per the project-specific planning documents.

> ***CAUTION***
> When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

NOTE
Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE
Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).

4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:

   - Enclose areas accessible by the general public using construction fencing and signs.

   - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.

   - Maintain the retaining bolt and label on the outside of storage containers where readily visible.

   - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.

   - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.

   - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 Decontamination Evaluation

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.

- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:

  - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.

  - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.

  - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:

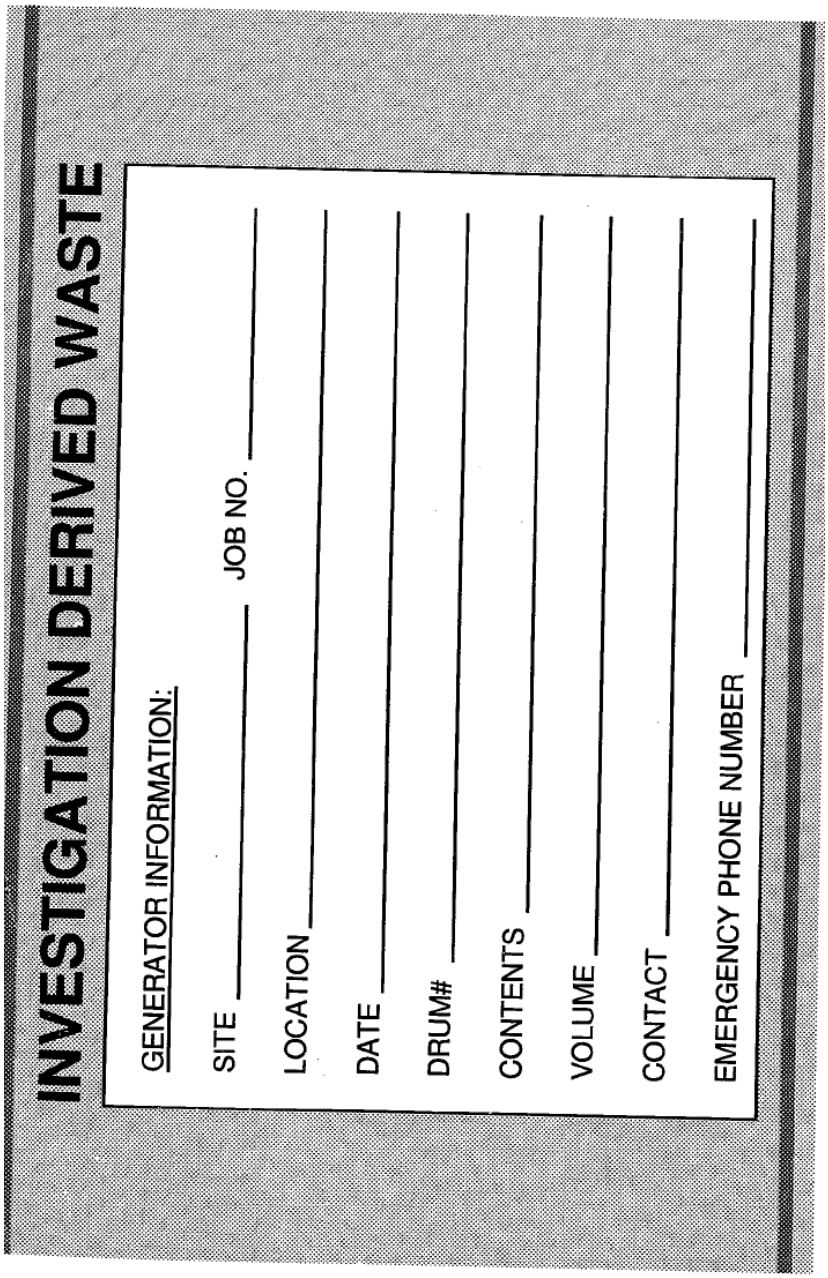
    - Per decontamination method
    - Per disposable article/batch number of disposable articles

NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.

Attachment A
iDW Label



U.S. ENVIRONMENTAL PROTECTION AGENCY REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUNDWATER SAMPLES FROM MONITORING WELLS

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USE OF TERMS

Equipment blank: The equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank needs only to include the pump in subsequent sampling rounds. If the pump and tubing are dedicated to the well, the equipment blank is collected prior to its placement in the well. If the pump and tubing will be used to sample multiple wells, the equipment blank is normally collected after sampling from contaminated wells and not after background wells.

Field duplicates: Field duplicates are collected to determine precision of the sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

Indicator field parameters: This SOP uses field measurements of turbidity, dissolved oxygen, specific conductance, temperature, pH, and oxidation/reduction potential (ORP) as indicators of when purging operations are sufficient and sample collection may begin.

Matrix Spike/Matrix Spike Duplicates: Used by the laboratory in its quality assurance program. Consult the laboratory for the sample volume to be collected.

Poteniometric Surface: The level to which water rises in a tightly cased well constructed in a confined aquifer. In an unconfined aquifer, the potentiometric surface is the water table.

QAPP: Quality Assurance Project Plan

SAP: Sampling and Analysis Plan

SOP: Standard operating procedure

Stabilization: A condition that is achieved when all indicator field parameter measurements are sufficiently stable (as described in the "Monitoring Indicator Field Parameters" section) to allow sample collection to begin.

Temperature blank: A temperature blank is added to each sample cooler. The blank is measured upon receipt at the laboratory to assess whether the samples were properly cooled during transit.

Trip blank (VOCs): Trip blank is a sample of analyte-free water taken to the sampling site and returned to the laboratory. The trip blanks (one pair) are added to each sample cooler that contains VOC samples.

SCOPE & APPLICATION

The goal of this groundwater sampling procedure is to collect water samples that reflect the total mobile organic and inorganic loads (dissolved and colloidal sized fractions) transported through the subsurface under ambient flow conditions, with minimal physical and chemical alterations from sampling operations. This standard operating procedure (SOP) for collecting groundwater samples will help ensure that the project's data quality objectives (DQOs) are met under certain low-flow conditions.

The SOP emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations. Indicator field parameters (e.g., dissolved oxygen, pH, etc.) are monitored during purging in order to determine when sample collection may begin. Samples properly collected using this SOP are suitable for analysis of groundwater contaminants (volatile and semi-volatile organic analytes, dissolved gases, pesticides, PCBs, metals and other inorganics), or naturally occurring analytes. This SOP is based on Puls, and Barcelona (1996).

This procedure is designed for monitoring wells with an inside diameter (1.5-inches or greater) that can accommodate a positive lift pump with a screen length or open interval ten feet or less and with a water level above the top of the screen or open interval (Hereafter, the "screen or open interval" will be referred to only as "screen interval"). This SOP is not applicable to other well-sampling conditions.

While the use of dedicated sampling equipment is not mandatory, dedicated pumps and tubing can reduce sampling costs significantly by streamlining sampling activities and thereby reducing the overall field costs.

The goal of this procedure is to emphasize the need for consistency in deploying and operating equipment while purging and sampling monitoring wells during each sampling event. This will help to minimize sampling variability.

This procedure describes a general framework for groundwater sampling. Other site specific information (hydrogeological context, conceptual site model (CSM), DQOs, etc.) coupled with systematic planning must be added to the procedure in order to develop an appropriate site specific SAP/QAPP. In addition, the site specific SAP/QAPP must identify the specific equipment that will be used to collect the groundwater samples.

This procedure does not address the collection of water or free product samples from wells containing free phase LNAPLs and/or DNAPLs (light or dense non-aqueous phase

liquids). For this type of situation, the reader may wish to check: Cohen, and Mercer (1993) or other pertinent documents.

This SOP is to be used when collecting groundwater samples from monitoring wells at all Superfund, Federal Facility and RCRA sites in Region 1 under the conditions described herein. Request for modification of this SOP, in order to better address specific situations at individual wells, must include adequate technical justification for proposed changes. All changes and modifications must be approved and included in a revised SAP/QAPP before implementation in field.

BACKGROUND FOR IMPLEMENTATION

It is expected that the monitoring well screen has been properly located (both laterally and vertically) to intercept existing contaminant plume(s) or along flow paths of potential contaminant migration. Problems with inappropriate monitoring well placement or faulty/improper well installation cannot be overcome by even the best water sampling procedures. This SOP presumes that the analytes of interest are moving (or will potentially move) primarily through the more permeable zones intercepted by the screen interval.

Proper well construction, development, and operation and maintenance cannot be overemphasized. The use of installation techniques that are appropriate to the hydrogeologic setting of the site often prevent "problem well" situations from occurring. During well development, or redevelopment, tests should be conducted to determine the hydraulic characteristics of the monitoring well. The data can then be used to set the purging/sampling rate, and provide a baseline for evaluating changes in well performance and the potential need for well rehabilitation. Note: if this installation data or well history (construction and sampling) is not available or discoverable, for all wells to be sampled, efforts to build a sampling history should commence with the next sampling event.

The pump intake should be located within the screen interval and at a depth that will remain under water at all times. It is recommended that the intake depth and pumping rate remain the same for all sampling events. The mid-point or the lowest historical midpoint of the saturated screen length is often used as the location of the pump intake. For new wells, or for wells without pump intake depth information, the site's SAP/QAPP must provide clear reasons and instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected. If the depths to top and bottom of the well screen are not known, the SAP/QAPP will need to describe how the sampling depth will be determined and how the data can be used.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU, and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection

may still take place provided the indicator field parameter criteria in this procedure are met. If after 2 hours of purging indicator field parameters have not stabilized, one of three optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization), c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may reflect a sampling bias and therefore, the data may not meet the data quality objectives of the sampling event).

It is recommended that low-flow sampling be conducted when the air temperature is above 32°F (0°C). If the procedure is used below 32°F, special precautions will need to be taken to prevent the groundwater from freezing in the equipment. Because sampling during freezing temperatures may adversely impact the data quality objectives, the need for water sample collection during months when these conditions are likely to occur should be evaluated during site planning and special sampling measures may need to be developed. Ice formation in the flow-through-cell will cause the monitoring probes to act erratically. A transparent flow-through-cell needs to be used to observe if ice is forming in the cell. If ice starts to form on the other pieces of the sampling equipment, additional problems may occur.

HEALTH & SAFETY

When working on-site, comply with all applicable OSHA requirements and the site's health/safety procedures. All proper personal protection clothing and equipment are to be worn. Some samples may contain biological and chemical hazards. These samples should be handled with suitable protection to skin, eyes, etc.

CAUTIONS

The following cautions need to be considered when planning to collect groundwater samples when the below conditions occur.

If the groundwater degasses during purging of the monitoring well, dissolved gases and VOCs will be lost. When this happens, the groundwater data for dissolved gases (e.g., methane, ethene, ethane, dissolved oxygen, etc.) and VOCs will need to be qualified. Some conditions that can promote degassing are the use of a vacuum pump (e.g., peristaltic pumps), changes in aperture along the sampling tubing, and squeezing/pinching the pump's tubing which results in a pressure change.

When collecting the samples for dissolved gases and VOCs analyses, avoid aerating the groundwater in the pump's tubing. This can cause loss of the dissolved gases and VOCs in

the groundwater. Having the pump's tubing completely filled prior to sampling will avoid this problem when using a centrifugal pump or peristaltic pump.

Direct sun light and hot ambient air temperatures may cause the groundwater in the tubing and flow-through-cell to heat up. This may cause the groundwater to degas which will result in loss of VOCs and dissolved gases. When sampling under these conditions, the sampler will need to shade the equipment from the sunlight (e.g., umbrella, tent, etc.). If possible, sampling on hot days, or during the hottest time of the day, should be avoided. The tubing exiting the monitoring well should be kept as short as possible to avoid the sun light or ambient air from heating up the groundwater.

Thermal currents in the monitoring well may cause vertical mixing of water in the well bore. When the air temperature is colder than the groundwater temperature, it can cool the top of the water column. Colder water which is denser than warm water sinks to the bottom of the well and the warmer water at the bottom of the well rises, setting up a convention cell. "During low-flow sampling, the pumped water may be a mixture of convecting water from within the well casing and aquifer water moving inward through the screen. This mixing of water during low-flow sampling can substantially increase equilibration times, can cause false stabilization of indicator parameters, can give false indication of redox state, and can provide biological data that are not representative of the aquifer conditions" (Vroblesky 2007).

Failure to calibrate or perform proper maintenance on the sampling equipment and measurement instruments (e.g., dissolved oxygen meter, etc.) can result in faulty data being collected.

Interferences may result from using contaminated equipment, cleaning materials, sample containers, or uncontrolled ambient/surrounding air conditions (e.g., truck/vehicle exhaust nearby).

Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and/or proper planning to avoid ambient air interferences. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

Clean and decontaminate all sampling equipment prior to use. All sampling equipment needs to be routinely checked to be free from contaminants and equipment blanks collected to ensure that the equipment is free of contaminants. Check the previous equipment blank data for the site (if they exist) to determine if the previous cleaning procedure removed the contaminants. If contaminants were detected and they are a concern, then a more vigorous cleaning procedure will be needed.

PERSONNEL QUALIFICATIONS

All field samplers working at sites containing hazardous waste must meet the requirements of the OSHA regulations. OSHA regulations may require the sampler to take the 40 hour OSHA health and safety training course and a refresher course prior to engaging in any field activities, depending upon the site and field conditions.

The field samplers must be trained prior to the use of the sampling equipment, field instruments, and procedures. Training is to be conducted by an experienced sampler before initiating any sampling procedure.

The entire sampling team needs to read, and be familiar with, the site Health and Safety Plan, all relevant SOPs, and SAP/QAPP (and the most recent amendments) before going onsite for the sampling event. It is recommended that the field sampling leader attest to the understanding of these site documents and that it is recorded.

EQUIPMENT AND SUPPLIES

A. Informational materials for sampling event

A copy of the current Health and Safety Plan, SAP/QAPP, monitoring well construction data, location map(s), field data from last sampling event, manuals for sampling, and the monitoring instruments' operation, maintenance, and calibration manuals should be brought to the site.

B. Well keys.

C. Extraction device

Adjustable rate, submersible pumps (e.g., centrifugal, bladder, etc.) which are constructed of stainless steel or Teflon are preferred. Note: if extraction devices constructed of other materials are to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

If bladder pumps are selected for the collection of VOCs and dissolved gases, the pump setting should be set so that one pulse will deliver a water volume that is sufficient to fill a 40 mL VOC vial. This is not mandatory, but is considered a "best practice". For the proper operation, the bladder pump will need a minimum amount of water above the pump; consult the manufacturer for the recommended submergence. The pump's recommended submergence value should be determined during the planning stage, since it may influence well construction and placement of dedicated pumps where water-level fluctuations are significant.

Adjustable rate, peristaltic pumps (suction) are to be used with caution when collecting samples for VOCs and dissolved gases (e.g., methane, carbon dioxide, etc.) analyses. Additional information on the use of peristaltic pumps can be found in Appendix A. If peristaltic pumps are used, the inside diameter of the rotor head tubing needs to match the inside diameter of the tubing installed in the monitoring well.

Inertial pumping devices (motor driven or manual) are not recommended. These devices frequently cause greater disturbance during purging and sampling, and are less easily controlled than submersible pumps (potentially increasing turbidity and sampling variability, etc.). This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

D. Tubing

Teflon or Teflon-lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. Note: if tubing constructed of other materials is to be used, adequate information must be provided to show that the substituted materials do not leach contaminants nor cause interferences to the analytical procedures to be used. Acceptance of these materials must be obtained before the sampling event.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for metal and other inorganics analyses.

The use of 1/4 inch or 3/8 inch (inside diameter) tubing is recommended. This will help ensure that the tubing remains liquid filled when operating at very low pumping rates when using centrifugal and peristaltic pumps.

Silastic tubing should be used for the section around the rotor head of a peristaltic pump. It should be less than a foot in length. The inside diameter of the tubing used at the pump rotor head must be the same as the inside diameter of tubing placed in the well. A tubing connector is used to connect the pump rotor head tubing to the well tubing. Alternatively, the two pieces of tubing can be connected to each other by placing the one end of the tubing inside the end of the other tubing. The tubing must not be reused.

E. The water level measuring device

Electronic "tape", pressure transducer, water level sounder/level indicator, etc. should be capable of measuring to 0.01 foot accuracy. Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each sampling event.

F. Flow measurement supplies

Graduated cylinder (size according to flow rate) and stopwatch usually will suffice.

Large graduated bucket used to record total water purged from the well.

G. Interface probe

To be used to check on the presence of free phase liquids (LNAPL, or DNAPL) before purging begins (as needed).

H. Power source (generator, nitrogen tank, battery, etc.)

When a gasoline generator is used, locate it downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate samples.

I. Indicator field parameter monitoring instruments

Use of a multi-parameter instrument capable of measuring pH, oxidation/reduction potential (ORP), dissolved oxygen (DO), specific conductance, temperature, and coupled with a flow-through-cell is required when measuring all indicator field parameters, except turbidity. Turbidity is collected using a separate instrument. Record equipment/instrument identification (manufacturer, and model number).

Transparent, small volume flow-through-cells (e.g., 250 mLs or less) are preferred. This allows observation of air bubbles and sediment buildup in the cell, which can interfere with the operation of the monitoring instrument probes, to be easily detected. A small volume cell facilitates rapid turnover of water in the cell between measurements of the indicator field parameters.

It is recommended to use a flow-through-cell and monitoring probes from the same manufacturer and model to avoid incompatibility between the probes and flow-through-cell.

Turbidity samples are collected before the flow-through-cell. A "T" connector coupled with a valve is connected between the pump's tubing and flow-through-cell. When a turbidity measurement is required, the valve is opened to allow the groundwater to flow into a container. The valve is closed and the container sample is then placed in the turbidimeter.

Standards are necessary to perform field calibration of instruments. A minimum of two standards are needed to bracket the instrument measurement range for all parameters except ORP which use a Zobell solution as a standard. For dissolved oxygen, a wet sponge used for the 100% saturation and a zero dissolved oxygen solution are used for the calibration.

Barometer (used in the calibration of the Dissolved Oxygen probe) and the conversion formula to convert the barometric pressure into the units of measure used by the Dissolved Oxygen meter are needed.

J. Decontamination supplies

Includes (for example) non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.

K. Record keeping supplies

Logbook(s), well purging forms, chain-of-custody forms, field instrument calibration forms, etc.

L. Sample bottles

M. Sample preservation supplies (as required by the analytical methods)

N. Sample tags or labels

O. PID or FID instrument

If appropriate, to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

P. Miscellaneous Equipment

Equipment to keep the sampling apparatus shaded in the summer (e.g., umbrella) and from freezing in the winter. If the pump's tubing is allowed to heat up in the warm weather, the cold groundwater may degas as it is warmed in the tubing.

EQUIPMENT/INSTRUMENT CALIBRATION

Prior to the sampling event, perform maintenance checks on the equipment and instruments according to the manufacturer's manual and/or applicable SOP. This will ensure that the equipment/instruments are working properly before they are used in the field.

Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments are calibrated using U.S Environmental Protection Agency Region 1 *Calibration of Field Instruments (temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction [ORP], and turbidity),* January 19, 2010, or latest version or from one of the methods listed in 40CFR136, 40CFR141 and SW-846.

The instruments shall be calibrated at the beginning of each day. If the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. If the field instruments are being used to monitor the natural attenuation parameters, then a calibration check at mid-day is highly recommended to ensure that the instruments did not drift out of calibration. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be qualified or rejected.

PRELIMINARY SITE ACTIVITIES (as applicable)

Check the well for security (damage, evidence of tampering, missing lock, etc.) and record pertinent observations (include photograph as warranted).

If needed lay out sheet of clean polyethylene for monitoring and sampling equipment, unless equipment is elevated above the ground (e.g., on a table, etc.).

Remove well cap and if appropriate measure VOCs at the rim of the well with a PID or FID instrument and record reading in field logbook or on the well purge form.

If the well casing does not have an established reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook (consider a photographic record as well). All water level measurements must be recorded relative to this reference point (and the altitude of this point should be determined using techniques that are appropriate to site's DQOs.

If water-table or potentiometric surface map(s) are to be constructed for the sampling event, perform synoptic water level measurement round (in the shortest possible time) before any purging and sampling activities begin. If possible, measure water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) the day before sampling begins, in order to allow for re-settlement of any particulates in the water column. This is especially important for those wells that have not been recently sampled because sediment buildup in the well may require the well to be redeveloped. If measurement of total well depth is not made the day before, it should be measured after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe may not be necessary unless analytical data or field analysis signal a worsening situation. This SOP cannot be used in the presence of LNAPLs or DNAPLs. If NAPLs are present, the project team must decide upon an alternate sampling method. All project modifications must be approved and documented prior to implementation.

If available check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the intake depth or extraction rate(s) used during previous sampling event(s), for either portable or dedicated extraction devices, record new values, and explain reasons for the changes in the field logbook.

PURGING AND SAMPLING PROCEDURE

Purging and sampling wells in order of increasing chemical concentrations (known or anticipated) are preferred.

The use of dedicated pumps is recommended to minimize artificial mobilization and entrainment of particulates each time the well is sampled. Note that the use of dedicated sampling equipment can also significantly reduce the time needed to complete each

sampling event, will promote consistency in the sampling, and may reduce sampling bias by having the pump's intake at a constant depth.

A. Initial Water Level

Measure the water level in the well before installing the pump if a non-dedicated pump is being used. The initial water level is recorded on the purge form or in the field logbook.

B. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the appropriate depth (may not be the mid-point of the screen/open interval). The Sampling and Analysis Plan/Quality Assurance Project Plan should specify the sampling depth (used previously), or provide criteria for selection of intake depth for each new well. If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well.

Pump tubing lengths, above the top of well casing should be kept as short as possible to minimize heating the groundwater in the tubing by exposure to sun light and ambient air temperatures. Heating may cause the groundwater to degas, which is unacceptable for the collection of samples for VOC and dissolved gases analyses.

C. Measure Water Level

Before starting pump, measure water level. Install recording pressure transducer, if used to track drawdowns, to initialize starting condition.

D. Purge Well

From the time the pump starts purging and until the time the samples are collected, the purged water is discharged into a graduated bucket to determine the total volume of groundwater purged. This information is recorded on the purge form or in the field logbook.

Start the pump at low speed and slowly increase the speed until discharge occurs. Check water level. Check equipment for water leaks and if present fix or replace the affected equipment. Try to match pumping rate used during previous sampling event(s). Otherwise, adjust pump speed until there is little or no water level drawdown. If the minimal drawdown that can be achieved exceeds 0.3 feet, but remains stable, continue purging.

Monitor and record the water level and pumping rate every five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump to ensure stabilization of the water level. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" somewhat as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. If the initial water level is above the top of the screen do not allow the water level to fall into the well screen. The final purge volume must be greater than the stabilized drawdown volume plus the pump's tubing volume. If the drawdown has exceeded 0.3 feet and stabilizes, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are collected.

Avoid the use of constriction devices on the tubing to decrease the flow rate because the constrictor will cause a pressure difference in the water column. This will cause the groundwater to degas and result in a loss of VOCs and dissolved gasses in the groundwater samples.

Note: the flow rate used to achieve a stable pumping level should remain constant while monitoring the indicator parameters for stabilization and while collecting the samples.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (e.g., bladder, peristaltic), and/or the use of dedicated equipment. For new monitoring wells, or wells where the following situation has not occurred before, if the recovery rate to the well is less than 50 mL/min., or the well is being essentially dewatered during purging, the well should be sampled as soon as the water level has recovered sufficiently to collect the volume needed for all anticipated samples. The project manager or field team leader will need to make the decision when samples should be collected, how the sample is to be collected, and the reasons recorded on the purge form or in the field logbook. A water level measurement needs to be performed and recorded before samples are collected. If the project manager decides to collect the samples using the pump, it is best during this recovery period that the pump intake tubing not be removed, since this will aggravate any turbidity problems. Samples in this specific situation may be collected without stabilization of indicator field parameters. Note that field conditions and efforts to overcome problematic situations must be recorded in order to support field decisions to deviate from normal procedures described in this SOP. If this type of problematic situation persists in a well, then water sample collection should be changed to a passive or no-purge method, if consistent with the site's DQOs, or have a new well installed.

E. Monitor Indicator Field Parameters

After the water level has stabilized, connect the "T" connector with a valve and the flow-through-cell to monitor the indicator field parameters. If excessive turbidity is anticipated or encountered with the pump startup, the well may be purged for a while without connecting up the flow-through-cell, in order to minimize particulate buildup in the cell (This is a judgment call made by the sampler). Water level drawdown measurements should be made as usual. If possible, the pump may be installed the day before purging to allow particulates that were disturbed during pump insertion to settle.

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, ORP, DO) at a frequency of five minute intervals or greater. The pump's flow rate must be able to "turn over" at least one flow-through-cell volume between measurements (for a 250 mL flow-through-cell with a flow rate of 50 mLs/min., the monitoring frequency would be every five minutes; for a 500 mL flow-through-cell it would be every ten minutes). If the cell volume cannot be replaced in the five minute interval, then the time between measurements must be increased accordingly. Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments followed by stabilization of indicator parameters. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings are within the following limits:

Turbidity (10% for values greater than 5 NTU; if three Turbidity values are less than 5 NTU, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Samples for turbidity measurements are obtained before water enters the flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities. Record start and stop times and give a brief description of cleaning activities.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45 degree angle with the port facing upward can help remove bubbles from the flow-through-cell (see Appendix B Low-Flow Setup Diagram). All during the measurement process, the flow-through-cell must remain free of any gas bubbles. Otherwise, the monitoring probes may act erratically. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

F. Collect Water Samples

When samples are collected for laboratory analyses, the pump's tubing is disconnected from the "T" connector with a valve and the flow-through-cell. The samples are collected directly from the pump's tubing. Samples must not be collected from the flow-through-cell or from the "T" connector with a valve.

VOC samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

If the pump's flow rate is too high to collect the VOC/dissolved gases samples, collect the other samples first. Lower the pump's flow rate to a reasonable rate and collect the VOC/dissolved gases samples and record the new flow rate.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use the following procedure to collect samples: collect non-VOC/dissolved gases samples first, then increase flow rate slightly until the water completely fills the tubing, collect the VOC/dissolved gases samples, and record new drawdown depth and flow rate.

For bladder pumps that will be used to collect VOC or dissolved gas samples, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL VOC vial.

Use pre-preserved sample containers or add preservative, as required by analytical methods, to the samples immediately after they are collected. Check the analytical methods (e.g. EPA SW-846, 40 CFR 136, water supply, etc.) for additional information on preservation.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter (transparent housing preferred) is required, and the filter size (0.45 μm is commonly used) should be based on the sampling objective. Pre-rinse the filter with groundwater prior to sample collection. Make sure the filter is free of air bubbles before samples are collected. Preserve the filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in groundwater for human health or ecological risk calculations.

Label each sample as collected. Samples requiring cooling will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

G. Post Sampling Activities

If a recording pressure transducer is used to track drawdown, re-measure water level with tape.

After collection of samples, the pump tubing may be dedicated to the well for re-sampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth annually is usually sufficient after the initial low stress sampling event. However, a greater frequency may be needed if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and then following sampling of each well. Pumps should not be removed between purging and sampling operations. The pump, tubing, support cable and electrical wires which were in contact with the well should be decontaminated by one of the procedures listed below.

The use of dedicated pumps and tubing will reduce the amount of time spent on decontamination of the equipment. If dedicated pumps and tubing are used, only the initial sampling event will require decontamination of the pump and tubing.

Note if the previous equipment blank data showed that contaminant(s) were present after using the below procedure or the one described in the SAP/QAPP, a more vigorous procedure may be needed.

Procedure 1

Decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump and tubing. The pump may be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Optional - flush with isopropyl alcohol (pesticide grade; must be free of ketones {e.g., acetone}) or with methanol. This step may be required if the well is highly contaminated or if the equipment blank data from the previous sampling event show that the level of contaminants is significant.

Flush with distilled/deionized water. This step must remove all traces of alcohol (if used) from the equipment. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the groundwater samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. Quality control samples include field duplicates, equipment blanks, matrix spike/matrix spike duplicates, trip blanks (VOCs), and temperature blanks.

FIELD LOGBOOK

A field log shall be kept to document all groundwater field monitoring activities (see Appendix C, example table), and record the following for each well:

Site name, municipality, state.

Well identifier, latitude-longitude or state grid coordinates.

Measuring point description (e.g., north side of PVC pipe).

Well depth, and measurement technique.

Well screen length.

Pump depth.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, calculated or measured total volume pumped, and clock time of each set of measurements.

Type of tubing used and its length.

Type of pump used.

Clock time of start and end of purging and sampling activity.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analyses.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions, including approximate ambient air temperature.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling/monitoring equipment used, including trade names, model number, instrument identification number, diameters, material composition, etc.

DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, field indicator parameters measured during purging, field instrument calibration information, and whatever other field logbook information is needed to allow for a full evaluation of data usability.

Note: the use of trade, product, or firm names in this sampling procedure is for descriptive purposes only and does not constitute endorsement by the U.S. EPA.

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APPENDIX A
PERISTALTIC PUMPS

Before selecting a peristaltic pump to collect groundwater samples for VOCs and/or dissolved gases (e.g., methane, carbon dioxide, etc.) consideration should be given to the following:

- The decision of whether or not to use a peristaltic pump is dependent on the intended use of the data.
- If the additional sampling error that may be introduced by this device is NOT of concern for the VOC/dissolved gases data's intended use, then this device may be acceptable.
- If minor differences in the groundwater concentrations could effect the decision, such as to continue or terminate groundwater cleanup or whether the cleanup goals have been reached, then this device should NOT be used for VOC/dissolved gases sampling. In these cases, centrifugal or bladder pumps are a better choice for more accurate results.

EPA and USGS have documented their concerns with the use of the peristaltic pumps to collect water sample in the below documents.

- "Suction Pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" *A Compendium of Superfund Field Operations Methods*, EPA/540/P-87/001, December 1987.
- "The agency does not recommend the use of peristaltic pumps to sample ground water particularly for volatile organic analytes" *RCRA Ground-Water Monitoring Draft Technical Guidance*, EPA Office of Solid Waste, November 1992.
- "The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and volatiles loss", *Low-flow (Minimal drawdown) Ground-Water Sampling Procedures*, by Robert Puls & Michael Barcelona, April 1996, EPA/540/S-95/504.
- "Suction-lift pumps, such as peristaltic pumps, can operate at a very low pumping rate; however, using negative pressure to lift the sample can result in the loss of volatile analytes", USGS Book 9 Techniques of Water-Resources Investigation, Chapter A4. (Version 2.0, 9/2006).

APPENDIX B

SUMMARY OF SAMPLING INSTRUCTIONS

These instructions are for using an adjustable rate, submersible pump or a peristaltic pump with the pump's intake placed at the midpoint of a 10 foot or less well screen or an open interval. The water level in the monitoring well is above the top of the well screen or open interval, the ambient temperature is above 32°F, and the equipment is not dedicated. Field instruments are already calibrated. The equipment is setup according to the diagram at the end of these instructions.

1. Review well installation information. Record well depth, length of screen or open interval, and depth to top of the well screen. Determine the pump's intake depth (e.g., mid-point of screen/open interval).

2. On the day of sampling, check security of the well casing, perform any safety checks needed for the site, lay out a sheet of polyethylene around the well (if necessary), and setup the equipment. If necessary a canopy or an equivalent item can be setup to shade the pump's tubing and flow-through-cell from the sun light to prevent the sun light from heating the groundwater.

3. Check well casing for a reference mark. If missing, make a reference mark. Measure the water level (initial) to 0.01 ft. and record this information.

4. Install the pump's intake to the appropriate depth (e.g., midpoint) of the well screen or open interval. Do not turn-on the pump at this time.

5. Measure water level and record this information.

6. Turn-on the pump and discharge the groundwater into a graduated waste bucket. Slowly increase the flow rate until the water level starts to drop. Reduce the flow rate slightly so the water level stabilizes. Record the pump's settings. Calculate the flow rate using a graduated container and a stop watch. Record the flow rate. Do not let the water level drop below the top of the well screen.

If the groundwater is highly turbid or colored, continue to discharge the water into the bucket until the water clears (visual observation); this usually takes a few minutes. The turbid or colored water is usually from the well being disturbed during the pump installation. If the water does not clear, then you need to make a choice whether to continue purging the well (hoping that it will clear after a reasonable time) or continue to

the next step. Note, it is sometimes helpful to install the pump the day before the sampling event so that the disturbed materials in the well can settle out.

If the water level drops to the top of the well screen during the purging of the well, stop purging the well, and do the following:

> Wait for the well to recharge to a sufficient volume so samples can be collected. This may take awhile (pump maybe removed from well, if turbidity is not a problem). The project manager will need to make the decision when samples should be collected and the reasons recorded in the site's log book. A water level measurement needs to be performed and recorded before samples are collected. When samples are being collected, the water level must not drop below the top of the screen or open interval. Collect the samples from the pump's tubing. Always collect the VOCs and dissolved gases samples first. Normally, the samples requiring a small volume are collected before the large volume samples are collected just in case there is not sufficient water in the well to fill all the sample containers. All samples must be collected, preserved, and stored according to the analytical method. Remove the pump from the well and decontaminate the sampling equipment.

If the water level has dropped 0.3 feet or less from the initial water level (water level measure before the pump was installed); proceed to Step 7. If the water level has dropped more than 0.3 feet, calculate the volume of water between the initial water level and the stabilized water level. Add the volume of the water which occupies the pump's tubing to this calculation. This combined volume of water needs to be purged from the well after the water level has stabilized before samples are be collected.

7. Attach the pump's tubing to the "T" connector with a valve (or a three-way stop cock). The pump's tubing from the well casing to the "T" connector must be as short as possible to prevent the groundwater in the tubing from heating up from the sun light or from the ambient air. Attach a short piece of tubing to the other end of the end of the "T" connector to serve as a sampling port for the turbidity samples. Attach the remaining end of the "T" connector to a short piece of tubing and connect the tubing to the flow-through-cell bottom port. To the top port, attach a small piece of tubing to direct the water into a calibrated waste bucket. Fill the cell with the groundwater and remove all gas bubbles from the cell. Position the flow-through-cell in such a way that if gas bubbles enter the cell they can easily exit the cell. If the ports are on the same side of the cell and the cell is cylindrical shape, the cell can be placed at a 45-degree angle with the ports facing upwards; this position should keep any gas bubbles entering the cell away from the monitoring probes and allow the gas bubbles to exit the cell easily (see Low-Flow Setup Diagram). Note,

make sure there are no gas bubbles caught in the probes' protective guard; you may need to shake the cell to remove these bubbles.

8. Turn-on the monitoring probes and turbidity meter.

9. Record the temperature, pH, dissolved oxygen, specific conductance, and oxidation/reduction potential measurements. Open the valve on the "T" connector to collect a sample for the turbidity measurement, close the valve, do the measurement, and record this measurement. Calculate the pump's flow rate from the water exiting the flow-through-cell using a graduated container and a stop watch, and record the measurement. Measure and record the water level. Check flow-through-cell for gas bubbles and sediment; if present, remove them.

10. Repeat Step 9 every 5 minutes or as appropriate until monitoring parameters stabilized. Note at least one flow-through-cell volume must be exchanged between readings. If not, the time interval between readings will need to be increased. Stabilization is achieved when three consecutive measurements are within the following limits:

Turbidity (10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized),
Dissolved Oxygen (10% for values greater than 0.5 mg/L, if three Dissolved Oxygen values are less than 0.5 mg/L, consider the values as stabilized),
Specific Conductance (3%),
Temperature (3%),
pH (± 0.1 unit),
Oxidation/Reduction Potential (±10 millivolts).

If these stabilization requirements do not stabilize in a reasonable time, the probes may have been coated from the materials in the groundwater, from a buildup of sediment in the flow-through-cell, or a gas bubble is lodged in the probe. The cell and the probes will need to be cleaned. Turn-off the probes (not the pump), disconnect the cell from the "T" connector and continue to purge the well. Disassemble the cell, remove the sediment, and clean the probes according to the manufacturer's instructions. Reassemble the cell and connect the cell to the "T" connector. Remove all gas bubbles from the cell, turn-on the probes, and continue the measurements. Record that the time the cell was cleaned.

11. When it is time to collect the groundwater samples, turn-off the monitoring probes, and disconnect the pump's tubing from the "T" connector. If you are using a centrifugal or peristaltic pump check the pump's tubing to determine if the tubing is completely filled with water (no air space).

All samples must be collected and preserved according to the analytical method. VOCs and dissolved gases samples are normally collected first and directly into pre-preserved sample containers. However, this may not be the case for all sampling locations; the SAP/QAPP should list the order in which the samples are to be collected based on the project's objective(s). Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

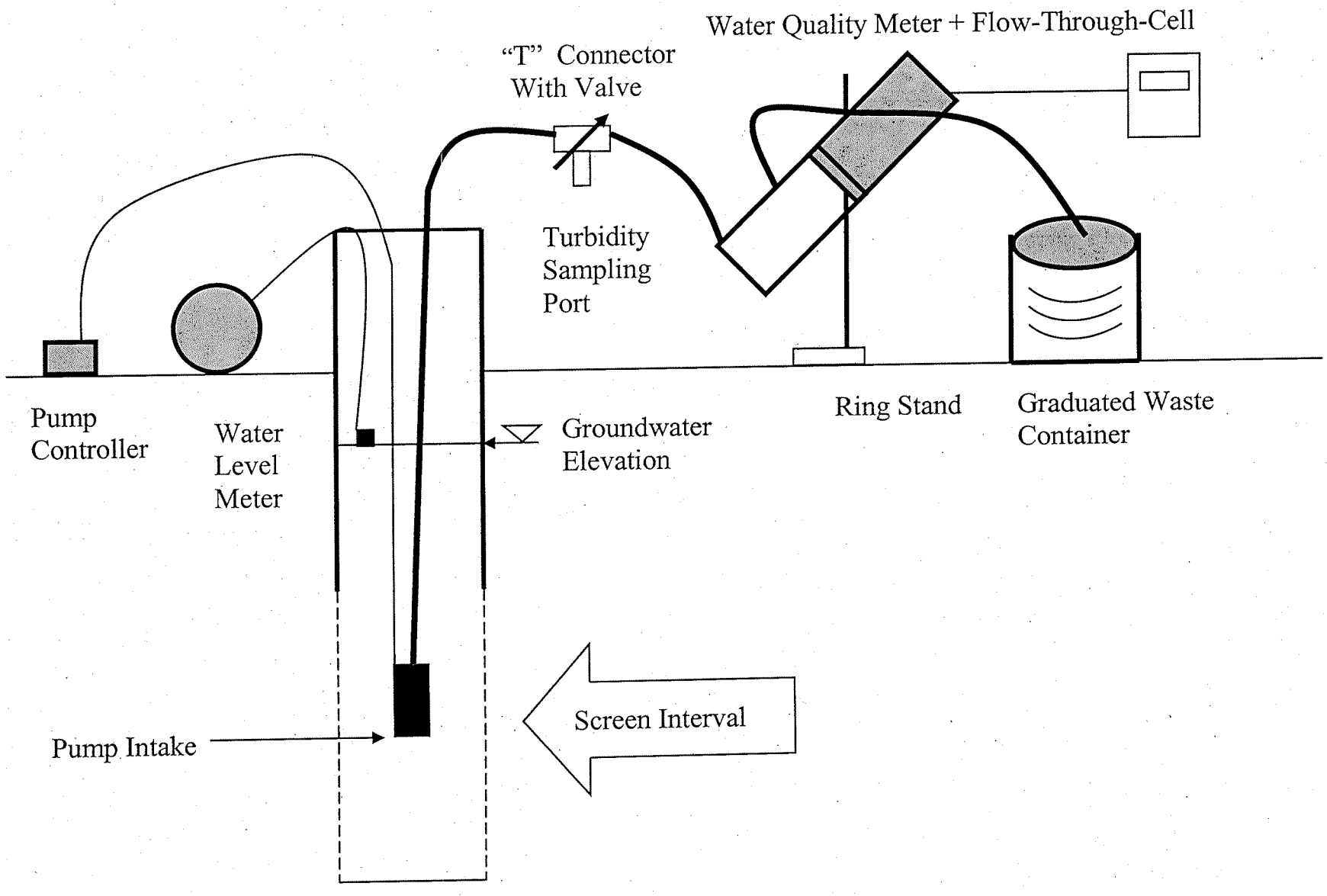
If the pump's tubing is not completely filled with water and the samples are being collected for VOCs and/or dissolved gases analyses using a centrifugal or peristaltic pump, do the following:

> All samples must be collected and preserved according to the analytical method. The VOCs and the dissolved gases (e.g., methane, ethane, ethene, and carbon dioxide) samples are collected last. When it becomes time to collect these samples increase the pump's flow rate until the tubing is completely filled. Collect the samples and record the new flow rate.

12. Store the samples according to the analytical method.

13. Record the total purged volume (graduated waste bucket). Remove the pump from the well and decontaminate the sampling equipment.

Low-Flow Setup Diagram



APPENDIX C
EXAMPLE (Minimum Requirements)
WELL PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)_____
Well Number_____ Date_____
Field Personnel_____
Sampling Organization_____
Identify MP_____

Depth to _____/_____ of screen
(below MP) top bottom
Pump Intake at (ft. below MP)_____
Purging Device; (pump type)_____
Total Volume Purged _____

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP[3] mv	DO mg/L	Turb-idity NTU	Comments
Stabilization Criteria					3%	3%	±0.1	± 10 mv	10%	10%	

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25 °C.
3. Oxidation reduction potential (ORP)

STANDARD OPERATING PROCEDURE
CALIBRATION OF FIELD INSTRUMENTS
(temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction potential [ORP], and turbidity)

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1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for groundwater and surface water. Water quality parameters include temperature, pH, dissolved oxygen, specific conductance, oxidation/reduction potential [ORP], and turbidity. This SOP supplements, but does not replace, EPA analytical methods listed in 40 CFR 136 and 40 CFR 141 for temperature, dissolved oxygen, conductivity/specific conductance, pH and turbidity.

This SOP is written for instruments that measure temperature, pH, dissolved oxygen, specific conductance, turbidity, and/or oxidation/reduction potential [ORP] and the probe readings for pH, dissolved oxygen, and specific conductance are automatically corrected for temperature.

For groundwater monitoring, the instrument must be equipped with a flow-through-cell and the display/logger or computer display screen needs to be large enough to simultaneously contain the readouts of each probe in the instrument. Turbidity is measured using a separate instrument. It must not be measured in a flow-through-cell because the flow-through-cell acts as a sediment trap. This procedure is applicable for use with the *EPA Region 1 Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells.*

2.0 HEALTH AND SAFETY WARNINGS

Read all labels on the standards and note any warnings on the labels. Wear appropriate personal protection equipment (e.g., gloves, eye shields, etc.) when handling the standards. If necessary, consult the Material Safety Data Sheets (MSDS) for additional safety information on the chemicals in the standards.

3.0 GENERAL

All monitoring instruments must be calibrated before they are used to measure environmental samples. For instrument probes that rely on the temperature sensor (pH, dissolved oxygen, specific conductance, and oxidation/reduction potential [ORP]), each temperature sensor needs to be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST). Before any instrument is calibrated or used to perform environmental measurements, the instrument must stabilize (warm-up) according to manufacturer's instructions and must have no air bubbles lodged between the probe and probe guard.

Most projects will require at least two standards to bracket the expected measurement range. This means that one standard is less than the expected value and one is higher. When an environmental sample measurement falls outside the calibration range, the instrument must be re-calibrated to bracket the new range before continuing measurements. Otherwise, the measurements that are outside the calibration range will need to be qualified.

This SOP requires that the manufacturer's instruction manual (including the instrument specifications) accompany the instrument into the field.

4.0 FREQUENCY OF CALIBRATION

At a minimum, the instrument is calibrated prior to use on the day the measurements are to be performed. A post calibration check at the end of the day is performed to determine if the instrument drifted out of calibration. Some projects may require more frequent calibration checks throughout the day in addition to the check at the end of the day. For these checks, the instrument can be recalibrated during the day if the instrument drifted out of calibration and only the data measured prior to the check would need to be qualified. The calibration/post calibration data information is recorded in Table 1.

Instruments (e.g., sonde) that monitor continuously over a period of time are calibrated before deployment. When these instruments are recovered, the calibration is checked to determine if any of them drifted out of calibration.

Some instruments lose their calibration criteria when they are turned off. Those instruments can either be left on all day (battery dependent) or calibrated at each sampling location. If they are calibrated at each sampling location, a post calibration check is not needed.

Ideally, the temperature of the standards should be close to the temperature of the ambient water that is being measured.

5.0 CALIBRATION PROCEDURES

Prior to calibration, all instrument probes and cable connections must be cleaned and the battery checked according to the manufacturer's instructions. Failure to perform these steps (proper maintenance) can lead to erratic measurements.

If a multi-probe instrument is to be used, program the instrument to display the parameters to be measured (e.g., temperature, pH, percent dissolved oxygen, mg/L dissolved oxygen, specific conductance, and ORP).

The volume of the calibration solutions must be sufficient to cover both the probe and temperature sensor (see manufacturer's instructions for the volume to be used).

Check the expiration date of the standards. Do not use expired standards.

All standards are stored according to manufacturer instructions.

5.1 TEMPERATURE

Most instrument manuals state there is no calibration of the temperature sensor, but the temperature sensor must be checked to determine its accuracy. This accuracy check is performed at least once per year and the accuracy check date/information is kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was over a year, the temperature sensor accuracy needs to be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor must be checked. This procedure is not normally perform in the field. If the instrument is obtained from a rental company, the rental company should performed the calibration check and include with the instrument documentation that it was performed.

Verification Procedure

1. Fill a container with water and adjust the water temperature to below the water body's temperature to be measured. Use ice or warm water to adjust the temperature.

2. Place a thermometer that is traceable to the National Institute of Standards and Technology (NIST) and the instrument's temperature sensor into the water. Wait for both temperature readings to stabilize.

3. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g., $\pm 0.2\,^{\circ}C$). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

4. Adjust the water temperature to a temperature higher than the water body to be measured.

5. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g.,

±0.2°C). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

5.2 pH (electrometric)

The pH of a sample is determined electrometrically using a glass electrode.

Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. If the water body's pH is unknown, then three standards are needed for the calibration: one close to seven, one at least two pH units below seven, and the other at least two pH units above seven. Instruments that will not accept three standards will need to be re-calibrated if the water sample's pH is outside the initial calibration range described by the two standards.

Calibration Procedure

1. Allow the buffered standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor.

3. Remove probe from its storage container, rinse with deionized water, and remove excess water.

4. Select measurement mode. Immerse probe into the initial standard (e.g., pH 7).

5. Wait until the readings stabilize. If the reading does not change within 30 seconds, select calibration mode and then select "pH". Enter the buffered standard value into instrument.

6. Remove probe from the initial standard, rinse with deionized water, and remove excess water.

7. Immerse probe into the second standard (e.g., pH 4). Repeat step 5.

8. Remove probe from the second standard, rinse with deionized water, and remove excess water. If instrument only accepts two standards, the calibration is complete. Go to step 11. Otherwise continue.

9. Immerse probe in third buffered standard (e.g., pH 10) and repeat step 5.

10. Remove probe from the third standard, rinse with deionized water, and remove excess water.

11. Select measurement mode, if not already selected. To ensure that the initial calibration standard (e.g., pH 7) has not changed, immerse the probe into the initial standard. Wait for the readings to stabilize. The reading should read the initial standard value within the manufacturer's specifications. If not, re-calibrate the instrument. If re-calibration does not help, the calibration range may be too great. Reduce calibration range by using standards that are closer together.

12. The calibration is complete. Rinse the probe with deionized water and store the probe according to manufacturer's instructions.

13. Record the calibration information on Table 1.

5.3 DISSOLVED OXYGEN

Dissolved oxygen (DO) content in water is measured using a membrane electrode. To insure proper operation, the DO probe's membrane and electrolyte should be replaced prior to calibration for the sampling event. The new membrane may need to be conditioned before it is used; consult manufacturer's manual on how the conditioning is to be performed. Failure to perform this step may lead to erratic measurements. Before performing the calibration/measurements, inspect the membrane for air bubbles and nicks.

Note: some manufacturers require an altitude correction instead of a barometric correction. In that case, enter the altitude correction according to the manufacturer's directions in Step 5 and then proceed to Step 6.

Note: some instruments have a built-in barometer. Follow the manufacturer's instructions for entering the barometric value in step 5.

<u>Calibration Procedure</u>

1. Gently dry the temperature sensor and remove any water droplets from the DO probe's sensor membrane according to manufacturer's instructions. Note that the evaporation of moisture on the temperature sensor or DO probe may influence the readings during calibration.

2. Create a 100 percent water-saturated air environment by placing a wet sponge or a

wet paper towel on the bottom of the DO calibration container. Place the DO probe into the calibration container. The probe is loosely fitted into the calibration container to prevent the escape of moisture evaporating from the sponge or paper towel while maintaining ambient pressure (see manufacturer's instructions). Note that the probe and the temperature sensor must not come in contact with these wet items.

3. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). During this time, turn on the instrument to allow the DO probe to warm-up. Select the measurement mode. Check the temperature readings. Readings must stabilize before continuing to the next step.

4. Select calibration mode; then select "DO %".

5. Enter the local barometric pressure (usually in mm of mercury) for the sampling location into the instrument. This measurement must be determined from an on-site barometer. Do not use barometric pressure obtained from the local weather services unless the pressure is corrected for the elevation of the sampling location. [Note: inches of mercury times 25.4 mm/inch equals mm of mercury or consult Oxygen Solubility at Indicated Pressure chart attached to the SOP for conversion at selected pressures].

6. The instrument should indicate that the calibration is in progress. After calibration, the instrument should display percent saturated DO.

7. Select measurement mode and set the display to read DO mg/L and temperature. Compare the DO mg/L reading to the Oxygen Solubility at Indicated Pressure chart attached to the SOP. The numbers should agree. If they do not agree within the accuracy of the instrument (usually ± 0.2 mg/L), repeat calibration. If this does not work, change the membrane and electrolyte solution.

8. Remove the probe from the container and place it into a 0.0 mg/L DO solution (see footnote). Check temperature readings. They must stabilize before continuing.

9. Wait until the "mg/L DO" readings have stabilized. The instrument should read less than 0.5 mg/L (assuming an accuracy of ± 0.2 mg/L). If the instrument reads above 0.5 mg/L or reads negative, it will be necessary to clean the probe, and change the membrane and electrolyte solution. If this does not work, try a new 0.0 mg/L DO solution. If these changes do not work, contact the manufacturer. Note: some projects and instruments may have different accuracy requirements. The 0.5 mg/L

value may need to be adjusted based on the accuracy requirements of the project or instrument.

10. After the calibration has been completed, rinse the probe with tap or deionized water and store the probe according to manufacturer's instructions. It is important that all of the 0.0 mg/L DO solution be rinsed off the probe so as not to effect the measurement of environmental samples.

11. Record calibration information on Table 1.

Note: You can either purchase the 0.0 mg/L DO solution from a vendor or prepare the solution yourself. To prepare a 0.0 mg/L DO solution, follow the procedure stated in Standard Methods (Method 4500-O G). The method basically states to add excess sodium sulfite (until no more dissolves) and a trace amount of cobalt chloride (read warning on the label before use) to water. This solution is prepared prior to the sampling event. Note: this solution can be made without cobalt chloride, but the probe will take longer to respond to the low DO concentration.

5.4 SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25°C.

Most instruments are calibrated against a single standard which is near the specific conductance of the environmental samples. The standard can be either below or above the specific conductance of the environmental samples. A second standard is used to check the linearity of the instrument in the range of measurements.

When performing specific conductance measurement on groundwater or surface water and the measurement is outside the initial calibration range defined by the two standards, the instrument will need to be re-calibrated using the appropriate standards.

<u>Specific Conductance Calibration Procedure</u>

1. Allow the calibration standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the standards so each standard will cover the probe and temperature sensor. Remove probe from its storage container, rinse the probe with deionized water or a small amount of the standard (discard the rinsate), and place the

probe into the standard.

3. Select measurement mode. Wait until the probe temperature has stabilized.

4. Select calibration mode, then specific conductance. Enter the specific conductance standard value. Make sure that the units on the standard are the same as the units used by the instrument. If not, convert the units on the standard to the units used by the instrument.

5. Select measurement mode. The reading should remain within manufacturer's specifications. If it does not, re-calibrate. If readings continue to change after re-calibration, consult manufacturer or replace calibration solution.

6. Remove probe from the standard, rinse the probe with deionized water or a small amount of the second standard (discard the rinsate), and place the probe into the second standard. The second standard will serve to verify the linearity of the instrument. Read the specific conductance value from the instrument and compare the value to the specific conductance on the standard. The two values should agree within the specifications of the instrument. If they do not agree, re-calibrate. If readings do not compare, then the second standard may be outside the linear range of the instrument. Use a standard that is closer to the first standard and repeat the verification. If values still do not compare, try cleaning the probe or consult the manufacturer.

7. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.

8. Record the calibration information on Table 1.

Note: for projects where specific conductance is not a critical measurement it may be possible to calibrate with one standard in the range of the expected measurement.

5.5 OXIDATION/REDUCTION POTENTIAL (ORP)

The oxidation/reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent.

Calibration or Verification Procedure

1. Allow the calibration standard (a Zobell solution: read the warning on the label before use) to equilibrate to ambient temperature.

2. Remove the probe from its storage container and place it into the standard.

3. Select measurement mode.

4. Wait for the probe temperature to stabilize, and then read the temperature.

5. If the instrument is to be calibrated, do Steps 6 and 7. If the instrument calibration is to be verified, then go to Step 8.

6. Look up the millivolt (mv) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. You may need to interpolate millivolt value between temperatures. Select "calibration mode", then "ORP". Enter the temperature-corrected ORP value into the instrument.

7. Select measurement mode. The readings should remain unchanged within manufacturer's specifications. If they change, re-calibrate. If readings continue to change after re-calibration, try a new Zobell solution or consult manufacturer. Go to Step 9.

8. If the instrument instruction manual states that the instrument is factory calibrated, then verify the factory calibration against the Zobell solution. If they do not agree within the specifications of the instrument, try a new Zobell solution. If it does not agree, the instrument will need to be re-calibrated by the manufacturer.

9. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.

10. Record the calibration information on Table 1.

5.6 TURBIDITY

The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A

turbidimeter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source. Note: the below calibration procedure is for a turbidimeter which the sample is placed into a cuvette.

Some instruments will only accept one standard. For those instruments, the second, third, etc., standards will serve as check points.

Calibration Procedures

1. Allow the calibration standards to equilibrate at the ambient temperature. The use of commercially available polymer primary standards (AMCO-AEPA-1) is preferred; however, the standards can be prepared using Formazin (read the warning on the label before use) according to the EPA analytical Method 180.1. Other standards may be used if they can be shown that they are equivalent to the previously mentioned standards.

2. If the standard cuvette is not sealed, rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe dry the inside of the cuvette because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.

3. Before performing the calibration procedure, make sure the cuvettes are not scratched and the outside surfaces are dry and free from fingerprints and dust. If the cuvette is scratched or dirty, discard or clean the cuvette respectively. Note: some manufacturers require the cuvette to be orientated in the instrument in a particular direction for accurate reading.

4. Select a low value standard such as a zero or 0.02 NTU and calibrate according to manufacturer's instructions. Note: a zero standard (approximately 0 NTU) can be prepared by passing distilled water through a 0.45 micron pore size membrane filter.

5. Select a high standard and calibrate according to manufacturer's instructions or verify the calibration if instrument will not accept a second standard. In verifying, the instrument should read the standard value to within the specifications of the instrument. If the instrument has range of scales, check each range that will be used during the sampling event with a standard that falls within that range.

6. Record the calibration information on Table 1.

6.0 POST CALIBRATION CHECK

After the initial calibration is performed, the instrument's calibration may drift during the measurement period. As a result, you need to determine the amount of drift that occurred after collecting the measurements. This is performed by placing the instrument in measurement mode (not calibration mode) and placing the probe in one or more of the standards used during the initial calibration; for turbidity place the standard in a cuvette and then into the turbidimeter. Wait for the instrument to stabilize and record the measurement (Table 1). Compare the measurement value to the initial calibration value. This difference in value is then compared to the drift criteria or post calibration criteria described in the quality assurance project plan or the sampling and analysis plan for the project. If the check value is outside the criteria, then the measurement data will need to be qualified.

For the dissolved oxygen calibration check, follow the calibration instructions steps one through three while the instrument is in measurement mode. Record dissolved oxygen value (mg/L), temperature, and barometric pressure. Compare the measurement value to the Oxygen Solubility at Indicated Pressure chart attached to this SOP. The value should be within the criteria specified for the project. If measurement value drifted outside the criteria, the data will need to be qualified.

If the quality assurance project plan or the sampling and analysis plan do not list the drift criteria or the post-calibration criteria, use the criteria below.

Measurement	**Post Calibration Criteria**
Dissolved Oxygen	± 0.5 mg/L of sat. value* < 0.5 mg/L for the 0 mg/L solution, but not a negative value
Specific Conductance	±5% of standard or ± 10 μS/cm (whichever is greater)
pH	± 0.3 pH unit with pH 7 buffer*
Turbidity	± 5% of standard
ORP	± 10 mv*

Note: * Table 8.1, USEPA Region 1 *YSI 6-Series Sondes and Data Logger SOP*, January 30, 2007, revision 9.

7.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All calibration records must be documented in the project's log book or on a calibration log sheet. At a minimum, include the instrument manufacturer, model number, instrument identification number (when more than one instrument of the same model is used), the standards used to calibrate the instruments (including source), the calibration date, the instrument readings, the post calibration check, and the name of the person(s) who performed the calibration. An example of a calibration log sheet is shown in Table 1.

8.0 References

Standard Methods for the Examination of Water and Wastewater, 20th edition, 1998.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Turbidity - Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, August 1993.

USEPA Region 1 YSI 6-Series Sondes and Data Logger SOP, January 30, 2007, revision 9.

USGS Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting, Techniques and Methods 1-D3.

TABLE 1
INSTRUMENT CALIBRATION LOG

Project Name_____ Date_____
Weather_____

Calibrated by_____ Instrument_____
Serial Number_____

Parameters	Morning Calibration	Morning Temperature	End of Day Calibration Check*	End of Day Temperature
Specific Conductance Standard #1				
Specific Conductance Standard #2				
pH (7)				
pH (4)				
pH (10)				
ORP Zobel solution				
Dissolved Oxygen 100% water saturated air mg/L				
Dissolved Oxygen Zero Dissolved Oxygen Solution mg/L				
Barometric Pressure mm Hg		NA		NA
Turbidity Standard #1				
Turbidity Standard #2				
Turbidity Standard #3				

* For each Parameter, chose one standard as your check standard. If possible, choose the one that is closest to the ambient measurement value.

Oxygen Solubility at Indicated Pressure

Temp.	Pressure (Hg)							
	760	755	750	745	740	735	730	mm
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	
3	13.43	13.34	13.25	13.16	13.07	12-98	12.90	
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	

(Continued)

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

Oxygen Solubility at Indicated Pressure (continued)

Temp.	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm
°C	28.54	28.35	28.15	27.95	27.76	27.56	27.36	27.17	in
0	13.89	13.80	13.70	13.61	13.51	13.41	13.32	13.22	mg/l
1	13.51	13.42	13.33	13.23	13.14	13.04	12.95	12.86	
2	13.15	13.06	12.07	12.88	12.79	12.69	12.60	12.51	
3	12.81	12.72	12.63	12.54	12.45	12.36	12.27	12.18	
4	12.47	12.39	12.30	12.21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11.98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.46	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	
40	6.10	6.06	6.01	5.96	5.92	5.86	5.83	5.78	
41	6.00	5.96	5.91	5.87	5.82	5.78	5.73	5.69	
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.60	
43	5.82	5.78	5.73	5.69	5.65	5.60	5.56	5.51	
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

APPENDIX B

FIELD FORMS

B-1 - FIELD FORMS

B-2 - HISTORIC BORING LOGS

B-1 FIELD FORMS

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: _____ BORING No.: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION			USCS *	Remarks	PID/FID Reading (ppm)			
					Soil Density/ Consistency or Rock Hardness	Color	Material Classification			Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): _____

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

Tetra Tech NUS, Inc.

CONTAINER SAMPLE & INSPECTION SHEET

Page_____ of _____

Project Site Name: _____
Project Number: _____
Site Identification: _____
Container Number(s): _____
Sample Type: [] Grab
[] Composite

Sample ID No. _____
Sampled By: _____
C.O.C. No.: _____
Concentration: [] High
[] Medium
[] Low

CONTAINER SOURCE

DRUM:
[] Bung Top
[] Lever Lock
[] Bolted Ring
[] Other _____

TANK:
[] Plastic
[] Metal
[] Other _____

OTHER: _____

CONTAINER DESCRIPTION

COLOR: _____

CONDITION: _____

MARKINGS: _____

VOL. OF CONTENTS: _____

OTHER: _____

CONTAINER DISPOSITION

SAMPLED: _____

OPENED BUT NOT SAMPLED:
Reason _____
_____

NOT OPENED:
Reason _____
_____

CONTENTS DESCRIPTION

SINGLE PHASED: _____
_____

MULTIPHASE :

	Layer 1	Layer 2	Layer 3
Phase (Sol. or Liq.)	_____	_____	_____
Color	_____	_____	_____
Viscosity	L, M or H	L, M or H	L, M orH
% of Total Volume	_____	_____	_____

MONITOR READING:

SAMPLE and /or INSPECTION DATE & TIME:
_____HRS.
METHOD:_____

SAMPLER(S) and / or INSPECTOR(S) SIGNATURE:

ANALYSIS:

Tetra Tech NUS, Inc.

PROJECT: _____ **JOB #:** _____
LOCATION: _____ **DATE:** _____
PROJECT MANAGER: _____ **FOL:** _____

DAILY ACTIVITIES CHECKLIST

Startup Checklist

Activity	Yes	No	N/A
Pertinent site activities/information entered into site logbook			
All onsite personnel listed in logbook			
Required medical information onsite for all workers (TtNUS and Subcontractors)			
Required MSDS's onsite			
Proper equipment calibrations performed (list equipment)			
1 _____			
2 _____			
3 _____			
4 _____			
Calibration logs filled out			
Tailgate H&S meeting held prior to beginning field activities			
Required work permits filled out/signed			
Required utility clearances obtained			
Required PPE onsite and in use			
Information required to be posted is in place			
(OSHA poster, hospital route, key phone numbers, etc.)			

Exit Checklist

Activity	Yes	No	N/A
Logbooks completely and comprehensively filled out			
Field forms complete and accounted for/properly filed			
Samples properly packaged/shipped			
COCs faxed to appropriate in-house personnel			
All equipment accounted for, on charge if needed, and properly secured			
All personnel accounted for			
Arrangements made for upcoming work (permits, clearances, equipment, etc.)			
Site properly secured			

Note - not all items listed apply to every job, and some additional requirements may apply on a job-specific basis.

Tetra Tech NUS, Inc.

DAILY ACTIVITIES RECORD

PROJECT NAME: _____ **PROJECT NUMBER:** _____

CLIENT: _____ **LOCATION:** _____

DATE: _____ **ARRIVAL TIME:** _____

Tt NUS PERSONNEL: _____ **DEPARTURE TIME:** _____

CONTRACTOR: _____ **DRILLER:** _____

ITEM	QUANTITY ESTIMATE	QUANTITY TODAY	PREVIOUS TOTAL QUANTITY	CUMULATIVE QUANTITY TO DATE

COMMENTS: _____

_____

_____

_____

APPROVED BY:

_____ _____

Tt NUS REPRESENTATIVE DRILLER

DATE: _____

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

TETRA TECH NUS
FIELD TASK MODIFICATION REQUEST FORM

Project/Installation Name _____ CTO & Project Number _____ Task Mod. Number _____

Modification To (e.g. Work Plan) _____ Site/Sample Location _____ Date _____

Activity Description: _____

Reason for Change: _____

Recommended Disposition: _____

Field Operations Leader (Signature) _____ Date _____

Approved Disposition:

Project/Task Order Manager (Signature) _____ Date _____

Distribution:

Program/Project File –
Project/Task Order Manager –
Field Operations Leader –

Other: _____

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: _____ **Project No.:** _____

Location: _____ **Personnel:** _____

Weather Conditions: _____ **Measuring Device:** _____

Tidally Influenced: Yes ____ No ____ **Remarks:** _____

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Total Well Depth (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Groundwater Elevation (feet)*	Comments

* All measurements to the nearest 0.01 foot

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Project Site Name: _____
Project No.: _____

[] Domestic Well Data
[] Monitoring Well Data
[] Other Well Type: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Time:	(Visual)	(S.U.)	(mS/cm)	(^{0}C)	(NTU)	(mg/l)	(%)	
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Method:								
Monitor Reading (ppm):								
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____ WELL ID.: _____

PROJECT NUMBER: _____ DATE: _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

SIGNATURE(S): _____

PAGE___OF___

Tetra Tech NUS, Inc.

MONITORING WELL DEVELOPMENT RECORD

Site: _____ Depth to Bottom (ft.): _____ Project Name: _____
Well: _____ Static Water Level Before (ft.): _____ Project Number: _____
Date Installed: _____ Static Water Level After (ft.): _____ Site Geologist: _____
Date Developed: _____ Screen Length (ft.): _____ Drilling Co.: _____
Dev. Method: _____ Specific Capacity: _____
Pump Type: _____ Casing ID (in.): _____

Time	Estimated Sediment Thickness (Ft.)	Cumulative Water Volume (Gal.)	Water Level Readings (Ft. below TOC)	Temperature (Degrees C)	pH	Specific Conductance (Units _____)	Turbidity (NTU)	Remarks (odor, color, etc.)

MONITORING WELL MATERIALS
CERTIFICATE OF CONFORMANCE

Well Designation:_____ Site Geologist: _____

Site Name: _____ Drilling Company: _____

Date Installed: _____ Driller:_____

Project Name: _____ Project Number: _____

Material	Brand/Description	Source/Supplier	Sample Collected ?
Well Casing			
Well Screen			
End Cap			
Drilling Fluid			
Drilling Fluid Additives			
Backfill Material			
Annular Filter Pack			
Bentonite Seal			
Annular Grout			
Surface Cement			
Protective Casing			
Paint			
Rod Lubricant			
Compressor Oil			

To the best of my knowledge, I certify that the above described materials were used during installation of this monitoring well.

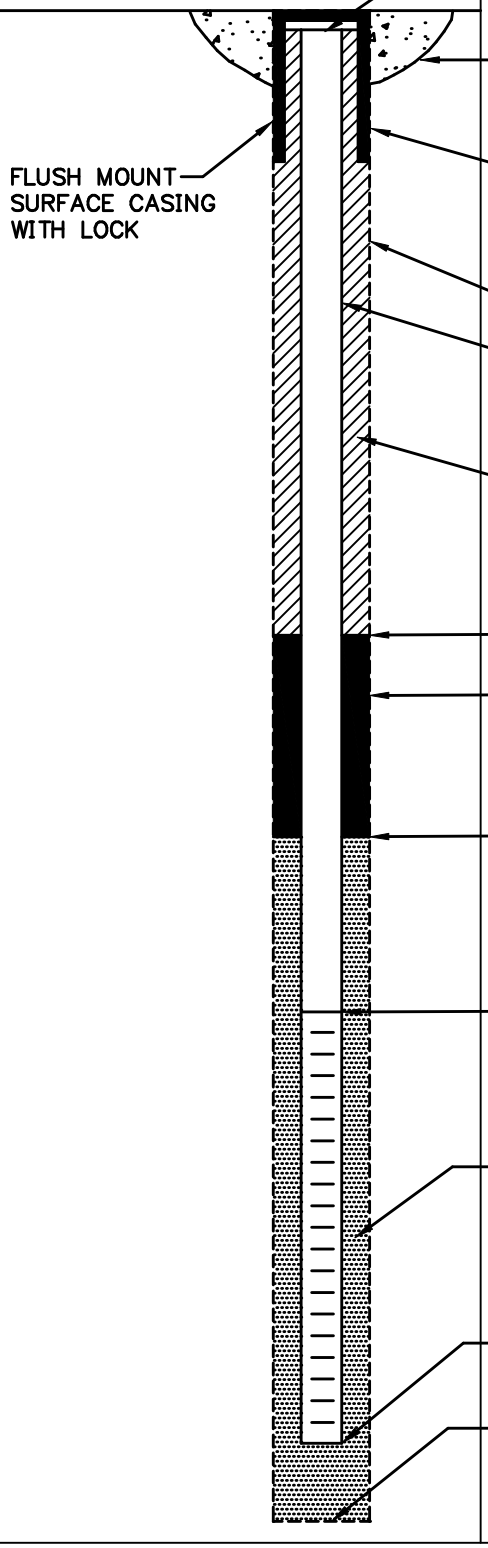
Signature of Site Geologist:_____

WELL NO.: _____

Tetra Tech NUS, Inc.

OVERBURDEN
MONITORING WELL SHEET
FLUSH - MOUNT

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
DATE BEGUN _____	DATE COMPLETED _____	
FIELD GEOLOGIST _____		DEVELOPMENT METHOD _____
GROUND ELEVATION _____	DATUM _____	



ELEVATION TOP OF RISER: _____

TYPE OF SURFACE SEAL: _____

TYPE OF PROTECTIVE CASING: _____

I.D. OF PROTECTIVE CASING: _____

DIAMETER OF HOLE: _____

TYPE OF RISER PIPE: _____

RISER PIPE I.D.: _____

TYPE OF BACKFILL/SEAL: _____

ELEVATION/DEPTH TOP OF SEAL: ____/____

TYPE OF SEAL: _____

ELEVATION/DEPTH TOP OF SAND: ____/____

ELEVATION/DEPTH TOP OF SCREEN: ____/____

TYPE OF SCREEN: _____

SLOT SIZE x LENGTH: _____

TYPE OF SAND PACK: _____

DIAMETER OF HOLE IN BEDROCK: _____

ELEVATION / DEPTH BOTTOM OF SCREEN: ____/____

ELEVATION / DEPTH BOTTOM OF SAND: ____/____

ELEVATION/DEPTH BOTTOM OF HOLE: ____/____

BACKFILL MATERIAL BELOW SAND: _____

ACAD:FORM_MWFM.dwg 07/20/99 INL

B-2 HISTORIC BORING LOGS

TABLE B-1
MONITORING WELL CONSTRUCTION INFORMATION
NSB-NLON
GROTON, CONNECTICUT

		Field Verified During 2007 Monitoring Well Inventory								Log Depth Minus Field Depth (rounded whole ft)	Well Log Documentation											Slug/Pump Test Results (K, ft/day)
Zone	Well Number	Northing (NAD 83)	Easting (NAD 83)	Well Completion	Hole Dia. (in)	Casing Material	Well Outer Casing	Depth to Water (ft)	Field Depth of Well (ft RP)		Log Total Depth (ft RP)	Ground Surface Elevation (NAVD 88)	Top Of Casing Elevation (NAVD 88)	Top Of Riser Elevation (NAVD 88)	Screened Aquifer	Screen Material	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Drilling Method	Depth to Seal (ft bgs)	Seal Material	
1	FOMW14	705477.50	1180721.10	Flush-mount	2	PVC	12" Diameter	9.71	10.02	0	10	10.56		10.29	overburden(fill/alluvium)	PVC	3.20	10.20	HSA	1.00	bentonite	
1	13MW7	705377.10	1180452.60	Flush-mount	2	PVC	12" Diameter				14	5.80		5.46	overburden (fill)	PVC	4.34	14.34	HSA	2.50	bentonite	158.00
1	13MW21	705485.90	1180525.60	Flush-mount	2	PVC	8" Diameter	5.60	12.60	2	15	6.64	6.64	6.31	overburden (fill)	PVC	5.00	15.00	HSA	2.50	bentonite pellets	
1	13MW19	705449.90	1180513.80	Flush-mount	2	PVC	8" Diameter	4.84	14.62	0	15	5.95	5.95	5.66	overburden (fill)	PVC	5.00	15.00	HSA	2.50	bentonite pellets	
1	13MW20	705513.30	1180578.40	Flush-mount	2	PVC	8" Diameter	7.47	14.60	-2	13	8.32	8.32	8.06	overburden (fill)	PVC	3.00	13.00	HSA	1.50	bentonite pellets	
4	13MW13	704363.70	1181030.60	Flush-mount	2	PVC	10" Diameter	6.03	14.33	0	14	6.55		6.11	overburden (fill/dredge)	PVC	4.60	14.60	HSA	2.50	bentonite	40.00
4	13MW14	704343.40	1180927.20	Flush-mount	2	PVC	8" Diameter	5.16	14.15	0	14	6.09		5.59	overburden (fill)	PVC	4.80	14.80	HSA	3.00	bentonite	576.00
4	13MW15	704310.30	1180916.90	Flush-mount	2	PVC					12	5.31		4.86	overburden (fill)	PVC	2.60	12.60	HSA	0.00	backfill	
4	NESO10	704284.40	1180956.40	Flush-mount	3	Other	10" Diameter	6.21	9.25	0	9	6.03		5.71	overburden (alluvium)	PVC	4.30	9.30				
4	NESO11	704286.80	1181077.60	Flush-mount	2	PVC	10" Diameter	6.04	8.77	-1	8	6.50		6.39	overburden (alluvium)	PVC	3.60	8.60				
5	19MW3	708438.10	1180160.40	Flush-mount	2	PVC	6" Diameter	5.19	5.22	1	6	4.79		4.50	overburden (alluvium)	PVC	2.30	6.30	HSA	2.00	bentonite	
5	19MW4	708333.00	1180178.20	Flush-mount	2	PVC					5	4.94		4.70	overburden (alluvium)	PVC	1.70	5.70	HSA	0.50	bentonite	
7	MW3-7RI	706602.50	1180250.84	Flush-mount	2	PVC	8" Diameter	3.86	8.35	0	8	4.67	4.67	4.27	overburden(fill)	PVC	3.00	8.00	HSA	1.00	#00 sand	
7	MW4-7RI	706758.13	1180277.23	Flush-mount	2	PVC	8" Diameter	6.31	9.90	-2	8	6.03	6.03	5.67	overburden(fill)	PVC	3.00	8.00	HSA	1.50	#00 sand	
7	20MW7	706694.80	1180254.90	Flush-mount	2	PVC					12	3.79		3.57	overburden (alluvium)	PVC	2.50	12.50	HSA	1.00	bentonite	

HSA - Hollow Stem Auger
K - Permeability
NA - Not Applicable
PVC - Polyvinyl Chloride
NAVD - North American Vertical Datum
NAD - North American Datum

Vertical elevations are provided using the 1982 Subase Datum. Elevations provided on Table B-1 are listed using the North American Vertical Datum of 1988 (NAVD 88) and all future elevations will be surveyed using NAVD 88.

BORING LOG 13 MW 7

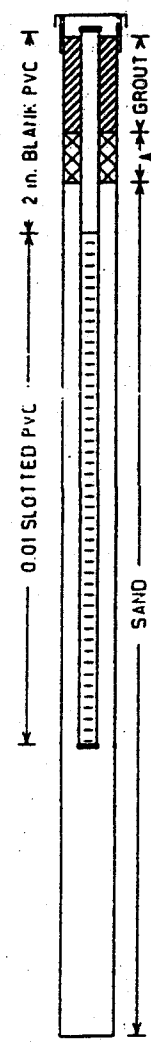
PROJECT: IR STUDY NSB - NLON
PROJECT NO: 1256-10
LOCATION: LOWER BASE
DATE STARTED: 11/07/90
DATA COMPLETED: 11/07/90
DRILLING CONTRACTOR: EMPIRE SOILS INVESTIGATIONS, INC.
DRILLER: TOM BROWN
DRILLING METHOD: HOLLOW STEM AUGER
SAMPLING METHOD: SPLIT SPOON

GROUND ELEVATION: 8.19
PROTECTIVE CASING ELEVATION: 8.19
WELL ELEVATION: 7.85
WATER LEVEL: 2.22 (03/21/91)
DATUM: SUBASE
WEATHER: 50°, PARTLY CLOUDY
INSPECTOR: ERIK NESS AND CURTIS NICHOLS
CHECKED BY: ERIK NESS

SPLIT SPOON SAMPLE DEPTH (ft)	BLOWS PER 6"	% RECOVERY	HNU (ppm)	SOIL DESCRIPTION (color, SOIL, admixture, moisture, other notes, ORIGIN)	DEPTH (FT.)	VISUAL CONTAM. NONE	STAIN	SHEEN	HEAVY	LEL %	RAD. (cpm)	SAMPLE ANALYSIS	LITHOLOGY	DEPTH (FT.)
0-2	AUGER 14 11	50	14.0	0.0 - 0.2 ASPHALT Brown, fine to coarse SAND and GRAVEL, some silt, damp.	0					1	60			0.0 0.2
2-4	10 12 13 9	0	NA	NO RECOVERY						NA	NA			2.0
4-6	6 5 4 3	25	13.5	Brown, fine to coarse SAND and GRAVEL, some silt, trace cobbles, damp	5					1	40			4.0 6.0
[illegible]	[illegible]	0	NA	NO RECOVERY						NA	NA			
8-10	5 5 4 5	50	24.0	Brown, medium to coarse SAND and GRAVEL, some cobbles, grading to grey stain, diesel odor, wet at 12.0 feet						1	40			8.0
10-12	[illegible] 5 [illegible]	5	30.0		10					1	40			
12-14	8 7 4 2	50	25.0	Brown, medium to coarse SAND and GRAVEL, some cobbles, wet						1	50			14.0
14-16	4 3 2 1	10	13.0	Grey, medium to coarse SAND, some gravel, wet	15					1	40			15.0
16-18	5 5 2 5	50	16.0	Grey, medium to coarse SAND and GRAVEL, wet						1	50			
18-20	3 3 2 2	90	12.0							1	60			
				Grey, fine SAND and SILT, trace clay, trace shell fragments, trace wood fragments, wet	20									19.7 20.0

END OF BORING AT 20.0 feet

WELL CONSTRUCTION



ATLANTIC

Vertical elevations are provided using the 1982 Subase Datum. Elevations provided on Table B-1 are listed using the North American Vertical Datum of 1988 (NAVD 88) and all future elevations will be surveyed using NAVD 88.

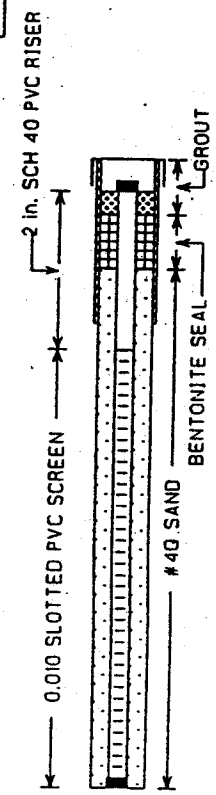
BORING LOG 19 MW 4

:CT: NAVY IR PROGRAM
PROJECT NO: 1245-15-02-03
LOCATION: PIER 33
DATE STARTED: 03/23/93
DATA COMPLETED: 03/23/93
DRILLING CONTRACTOR: COLUMBIA ENVIRONMENTAL DRILLING
DRILLER: GENE LEVESQUE
DRILLING METHOD: 4.25 IN. HOLLOW STEM AUGER
SAMPLING METHOD: 3 IN. SPLIT SPOON

GROUND ELEVATION: 7.33
PROTECTIVE CASING ELEVATION: 7.33
WELL ELEVATION: 7.09
WATER LEVEL: 3.92
DATUM: SUBASE
WEATHER: 50° PARTLY CLOUDY, WINDY
INSPECTOR: ERIK NESS
CHECKED BY: ERIK NESS

SAMPLE DEPTH (ft)	BLOWS PER 6"	% RECOVERY	HNU (ppm)	SOIL DESCRIPTION (color, SOIL, admixture, moisture, other notes, ORIGIN)	DEPTH (FT.)	VISUAL CONTAM. NONE	STAIN	SHEEN	HEAVY	SAMPLE ANALYSIS	LITHOLOGY	DEPTH (FT.)
				Weathered ASPHALT	0							0.0
0-2	29 20 39 26	80	0.0	Brown, fine to coarse SAND and GRAVEL, trace silt, moist								0.2
2-4	21 25 19 22	65	10.0	Dark brown stained, fine to coarse SAND and GRAVEL, strong petroleum odor, moist								
4-5.75	27 34 50/0.2	100	10.0	Wet at 5.0 feet.	5							
				Auger refusal at 5.75 feet, end of boring.	10							5.75

WELL CONSTRUCTION



ATLANTIC

Vertical elevations are provided using the 1982 Subase Datum. Elevations provided on Table B-1 are listed using the North American Vertical Datum of 1988 (NAVD 88) and all future elevations will be surveyed using NAVD 88.

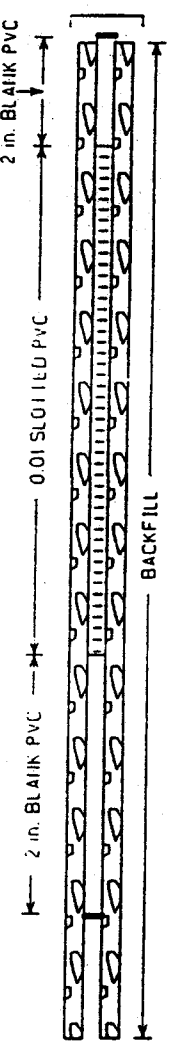
BORING LOG 13 MW 15

PROJECT: IR STUDY NSB - NLON
PROJECT NO: 1256-10
LOCATION: LOWER BASE
DATE STARTED: 11/12/90
DATA COMPLETED: 11/12/90
DRILLING CONTRACTOR: EMPIRE SOILS INVESTIGATIONS, INC.
DRILLER: TOM BROWN
DRILLING METHOD: HOLLOW STEM AUGER
SAMPLING METHOD: SPLIT SPOON

GROUND ELEVATION: 7.70
PROTECTIVE CASING ELEVATION: 7.70
WELL ELEVATION: 7.25
WATER LEVEL: 0.30 (03/21/91)
DATUM: SUBASE
WEATHER: 45°, CLEAR SKIES, WINDY
INSPECTOR: ERIK NESS AND CURTIS NICHOLS
CHECKED BY: ERIK NESS

SPLIT SPOON SAMPLE DEPTH (ft)	BLOWS PER 6"	% RECOVERY	HNU (ppm)	SOIL DESCRIPTION (color, SOIL, admixture, moisture, other notes, ORIGIN)	DEPTH (FT.)	VISUAL CONTAM. NONE	STAIN	SHEEN	HEAVY	LEL %	RAD. (cpm)	SAMPLE ANALYSIS	LITHOLOGY	DEPTH (FT.)
0-2	3 3 3 3	50	0.0	Light brown, fine to medium SAND, some gravel, damp	0					1	40			0.0
2-4	3 7 6 7	90	0.0							1	60			
4-6	8 7 8 6	90	5.0		5					1	60			
[illegible]	[illegible]	[illegible]	[illegible]	Light brown, medium to coarse SAND and GRAVEL, wet at 6.0 feet							50			6.0
8-10	8 5 6 8	50	14.0	Grading to grey						1	50			
10-12	2 1 [illegible]	50	16.0	Grading to dark brown stain	10					1	40			
12-14	[illegible]	50	16.0							1	40			
14-16	1 WOH WOH WOH	50	5.0	Grey, fine SAND and SILT, trace shell fragments, trace wood fragments, wet	15					1	40			14.0
16-18	1 WOH [illegible]	50	1.0							1	40			
18-20	[illegible]	0	NA	NO RECOVERY						NA	NA			18.0
				END OF BORING AT 20.0 feet	20									20.0

WELL CONSTRUCTION



ATLANTIC

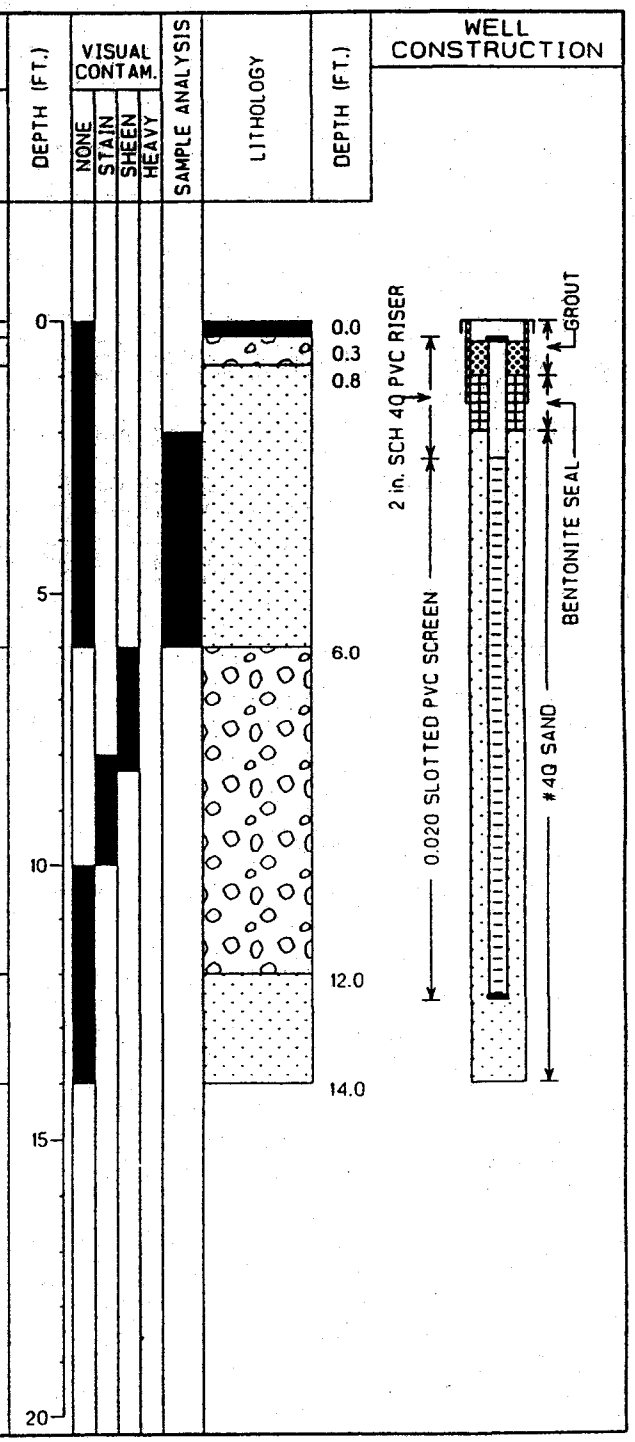
Vertical elevations are provided using the 1982 Subase Datum. Elevations provided on Table B-1 are listed using the North American Vertical Datum of 1988 (NAVD 88) and all future elevations will be surveyed using NAVD 88.

BORING LOG 20 MW 7

PROJECT: NAVY IR PROGRAM
PROJECT NO: 1245-15-02-02
LOCATION: BERTH 16
DATE STARTED: 03/30/93
DATA COMPLETED: 03/30/93
DRILLING CONTRACTOR: COLUMBIA ENVIRONMENTAL DRILLING
DRILLER: GENE LEVESQUE
DRILLING METHOD: 4.25 IN. HOLLOW STEM AUGER
SAMPLING METHOD: 3 IN. SPLIT SPOON

GROUND ELEVATION: 6.18
PROTECTIVE CASING ELEVATION: 6.18
WELL ELEVATION: 5.96
WATER LEVEL: 3.29
DATUM: SUBASE
WEATHER: 40° OVERCAST, RAIN
INSPECTOR: MARTIN BROGIE
CHECKED BY: ERIK NESS

SAMPLE DEPTH (ft)	BLOWS PER 6"	% RECOVERY	HNU (ppm)	SOIL DESCRIPTION (color, SOIL, admixture, moisture, other notes, ORIGIN)
0-2	23 23 17 18	100	14	ASPHALT; Dark brown, fine to medium SAND and GRAVEL, damp; Light brown, fine to medium SAND, trace gravel, no odor, damp
2-4	16 14 13 12	75	10	Light brown, fine to medium SAND, trace gravel, orange mottling at bottom, no odor, wet at bottom of spoon
4-6	8 8 7 7	45	7.0	Brown-gray, fine to medium SAND, trace gravel, moderate petroleum odor, wet
6-8	9 11 7 8	40	5.0	Gray-brown, fine to medium SAND and GRAVEL, trace cobbles, strong petroleum odor, and sheen, wet
8-10	11 10 8 7	35	4.0	Dark brown, fine to coarse SAND and GRAVEL, moderate petroleum odor and stain, slight sheen, wet; Dark brown, fine to coarse SAND and GRAVEL, moderate petroleum odor and stain, wet
10-12	13 7 8 10	20	6.0	Dark brown, fine to coarse SAND and GRAVEL, moderate petroleum odor, wet
12-14	4 5 4 4	10	2.0	Dark brown, fine to coarse SAND, trace gravel, trace cobbles, wet
				END OF BORING AT 14.0 FEET



ATLANTIC

APPENDIX C

LABORATORY TECHNICAL SPECIFICATION AND CERTIFICATION LETTER

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVE SE
WASHINGTON NAVY YARD DC 20376-0001

IN REPLY TO

5090
Ser 04XQ (LABS)/018
January 15, 2008

Mr. Lee Wolf
Columbia Analytical Services
1317 South 13th Avenue
Kelso, Washington 98626

Subj: COMPLETION LETTER REPORT, COLUMBIA ANALYTICAL SERVICES – KELSO, WASHINGTON

NAVSEA Laboratory Quality and Accreditation Office (LQAO) has concluded the assessment of Columbia Analytical Services (CAS) – Kelso located in Kelso, Washington.

The assessment was intended as a general review of analytical capability to support remediation projects and the laboratory's ability to meet quality assurance requirements of the Navy Environmental Restoration (ER) program. The specific methods reviewed under the assessment are summarized in the attached table. This letter presents the outcome of our assessment documented in the following reports:

LQAO ltr 5090 Ser 04XQ(LABS)/292 of 9 Nov 07
LQAO ltr 5090 Ser 04XQ(LABS)/296 of 27 Nov 07
LQAO ltr 5090 Ser 04XQ(LABS)/017 of 15 Jan 08

- **Desk Assessment:** A review of laboratory supplied documentation was conducted. Documentation included the laboratory's quality assurance (QA) manual, selected standard operating procedures (SOPs) and SOP master list, list of major analytical instrumentation, and historical PT information. The documentation was reflective of a laboratory that was in a position to meet Navy requirements; however findings that required resolution were identified.

- **Proficiency Testing (PT) Samples:** CAS - Kelso participates in a number of external certification and PT programs, and provided results for the past two years. The laboratory has provided documentation that demonstrates that they have successfully completed two PT samples for all analyses within the scope of the assessment.

5090
Ser 04XQ (LABS)/018
January 15, 2008

- **On-site Assessment:** Existing on-site assessment documentation is available and was applied to this assessment. The State of Florida Environmental Laboratory Accreditation Program (FL ELAP) conducted an on-site assessment of the laboratory on August 6 - 9, 2007. FL ELAP is a National Environmental Laboratory Accreditation Conference (NELAC) recognized accreditation body. The State of Florida accepted the corrective actions and accredited the laboratory effective August 20, 2007, expiring June 30, 2008. The nature of the findings did not raise a level of concern that would require a Navy follow-up on-site assessment.

- **Corrective Actions:** The Laboratory successfully remedied all of the Navy findings associated with the desk assessment.

The laboratory has provided documentation that demonstrates their capability to support environmental restoration projects (for the tests reviewed under this assessment, and summarized in the following table), and conformance to the DoD Quality Systems Manual. If you have questions concerning your standing in the Navy ER QA Program, please contact Pati Moreno at (805)982-1659.

Sincerely,

E. B. HARTZOG, JR.
Director, Laboratory Quality
and Accreditation Office

Copy To: NFESC (P. Moreno, Code 413)

CAS - Kelso - Methods Reviewed
(including parameters and matrices)

METHOD	PARAMETER	MATRIX
8260B	Analysis of Volatile Organic Compounds by GC/MS	Water/Solid
8270C/8270SIM	Analysis of Semivolatile Organic Compounds by GC/MS	Water/Solid
8082	Polychlorinated Biphenyls (PCBs) by Gas Chromatography	Water/Solid/Oil
6020/6010B/ 7000 Series	TAL Metals: Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, and Zinc	Water/Solid
300.0	Anions by Ion Chromatography	Water/Solid
314.0*	Perchlorate by 314.0	Water
8081A	Organochlorine Pesticides by Gas Chromatography	Water/Solid
8015B	Gasoline Range Organics/Diesel Range Organics	Water/Solid
9010B/9014	Total and Amenable Cyanides by Midi-Distillation	Water/Solid
7196A	Hexavalent Chromium	Water/Solid
8330	Analysis of Explosives by HPLC	Water/Solid
8310	Polynuclear Aromatic Hydrocarbons by HPLC	Water/Solid
8021	BTEX	Water/Solid
8151	Herbicides	Water/Solid

* EPA Method 314.0 cannot be used for DoD projects unless required by regulation. For perchlorate analysis, the DoD requires to the use of a mass spectrometry method.

-----Original Message-----
From: Moreno, Pati (NFESC) [mailto:pati.moreno@navy.mil]
Sent: Tuesday, February 05, 2008 1:39 PM
To: Lee Wolf
Cc: Neil, Kenda L. (NFESC)
Subject: Navy Assessment - CAS Kelso

Mr. Wolf,

This email addresses the status of Columbia Analytical Services (CAS) of Kelso, Washington in the Navy Environmental Restoration (ER) Quality Assurance (QA) Program as administered by the Naval Facilities Engineering Service Center (NFESC).

NAVSEA 04XQ conducted a laboratory assessment of Columbia Analytical Services (CAS) of Kelso, Washington as a support service to the Naval Facilities Engineering Service Center (NFESC). The general conclusion of the assessment is that the laboratory has successfully completed the evaluation for the parameters summarized in NAVSEA 04XQ letter Ser 04XQ (LABS)/018 dated January 15, 2008; these results are applicable to the Navy ER QA Program administered by NFESC. Based on the outcome of the assessment, a re-evaluation of your laboratory under the Navy ER QA Program will be due not later than August 9, 2009.

The outcome of this assessment does not guarantee the delivery of any analytical samples, and is facility specific (i.e. is not applicable to an affiliated or subcontract laboratory). The Navy reserves the right to conduct additional laboratory assessments. The outcome of the assessment may result in the addition or removal of parameters listed in the original scope of review, or reclassification from successful to unsuccessful.

Contact Ms. Kenda Neil (kenda.neil@navy.mil / 805 982-6060) if there are parameters not presented on the table in the aforementioned NAVSEA letter that the laboratory expects to run on a routine basis in support of Navy environmental restoration projects. In these circumstances the laboratory's capability to run the tests will be assessed and the table will be modified accordingly. Any other questions concerning the information provided should be directed to me.

Sincerely,
Pati Moreno
NFESC ER QA Program Coordinator
PH: (805) 982-1659 Fax: (805) 982-4304
Email: pati.moreno@navy.mil

ATTACHMENT NO. 2

STATEMENT OF WORK/PRICE TABLES

TECHNICAL SPECIFICATION FOR LABORATORY SERVICES
NAVAL SUBMARINE BASE (NSB), NEW LONDON, CT

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION - NAVY (CLEAN)
CONTRACT *N62470-08-D-1001,* CONTRACT TASK ORDER (CTO) NO. WE24

PRE-DESIGN GROUNDWATER REMEDIATION SAMPLING
CHEMICAL ANALYSES

1.0 INTRODUCTION

Tetra Tech NUS, Inc. (TtNUS) under CLEAN Contract ***N62470-08-D-1001*** is procuring laboratory analytical services for NSB New London, CT in support of Pre-Design Activities. Requested analyses include total and dissolved arsenic, copper, and lead.

The laboratory performing these analyses must be certified in the state of Connecticut. Additionally the laboratory must provide a copy of their NFESC approval letter, all methods requested must be addressed.

The responding laboratory must submit method detection limits (MDLs) and quantitation limits (QLs) for all analyses and matrices requested by filling out the last two columns of Attachment A and including the completed attachment with the bid response. After award, the laboratory will be required to submit Standard Operating Procedures (SOPs) and relevant precision and accuracy limits for all preparation and analytical methods required under this scope of work. The laboratory will also be asked to complete tables for inclusion in the Sampling and Analysis Plan (SAP). The SAP will be prepared according to the Uniform Federal Policy (UFP) for QAPPs (March 2005) and utilize the UFP SAP worksheets 1 through 37.

2.0 SAMPLE INFORMATION

Two rounds of groundwater samples will be shipped to the laboratory, one during the Fall of 2009 and the second in the Spring of 2010.

The approximate number of samples to be submitted, the type of analyses to be conducted, and the analytical methods to be used are summarized in the attached Table 1.

Field duplicate samples will be submitted with "blinded" identification to the laboratory. The field crew will designate samples (one per twenty samples of like matrices) upon which matrix spike/matrix spike duplicate (organic analyses) and matrix spike/laboratory duplicate (inorganic analyses) are to be performed; additional volumes of these samples will be provided as necessary.

All samples are expected to be of low or moderate contaminant concentrations. The field crew will attempt to identify any potentially high concentration samples.

For the ICP metal analyses, perform a matrix spike and a laboratory duplicate analysis instead of matrix spike/matrix spike duplicate. If the matrix spike recovery falls outside the control limits and the sample result does not exceed four times the spike added, a post-digestion spike analysis must be performed. In addition, a five-fold dilution analysis (serial dilution) must be performed on the field-designated QC sample. Results for these QC analyses must be summarized in the corresponding CLP-equivalent forms (Attachment B).

3.0 ANALYSIS/REPORTING INFORMATION

Data package deliverables must be submitted as a hardcopy and PDF (2 copies/2 CDs). The analytical requirements and approximate number of samples to be submitted for analysis are detailed in

Table 1. Any analysis and reporting requirements addressed in the DOD Quality Systems Manual (January 2006 or April 2009 depending on current NFESC approval letter) and the requested methods must be followed. Additionally, it is a requirement of TtNUS that the associated PDF data packages for PCBs and metals analysis must meet Contract Laboratory Program (CLP) format, reporting, and PDF data package deliverable requirements. The PDF data packages for all the remaining analyses must be fully validatable and contain raw data, summary forms for all sample and laboratory method blank data, and summary forms containing all method specific quality control (results, recoveries, relative percent differences, relative standard deviations, and/or percent differences etc.).

Additionally, each PDF data package must contain a summary data package. This summary data package shall consist of only the summary forms (i.e., for CLP Forms 1 through 15 and non-CLP it shall be the CLP-like equivalent of Forms 1 through 15).

Attachment A details the required target compound list and required QL goals that must be met. The laboratory must submit its MDLs and QLs for all analyses and matrices requested by filling out the last two columns of Attachment A and including the completed attachment with the bid response.

Attachment B details the required summary forms for CLP-like data packages, the requirements for the organization, and bookmarking of PDF data packages.

Non-detected metals results must be reported down to the MDLs submitted by the laboratory in Attachment A with the bid response. Positive results above the MDL but below the laboratory's QLs must be reported as estimated values qualified with a "J" **for metals** analyses.

The PDF data package deliverable must contain a detailed case narrative for all analytical fractions. This case narrative must also include the Contract Task Order (CTO) number, the site name, and the TtNUS Project Manager's name. Data from all analytical runs (i.e., original, dilution, re-analysis) must be reported. Additionally, the data package deliverable must include the ORIGINAL chain-of-custody form (received with the samples and signed by the laboratory sample custodian).

As stipulated in the CLEAN Master Services Agreement (MSA), Sample Delivery Group (SDG) and fractionally-specific text (TXT) files containing all environmental sample and field quality control blank analysis results must be generated in accordance with the requirements outlined in Attachment C of this specification.

As part of the laboratory case narrative, it is required that the Laboratory Quality Assurance Manager sign an attestation statement verifying that all electronic diskette deliverables exactly match the data summary forms (i.e. Form Is).

Maximum holding time allowances, as defined in the following table, are to be strictly observed. Calculation of holding time is in calendar days and is to begin from the time of collection. The holding times are as follows:

Analyses	Holding Time
Metals	6 months to analysis

These holding times are based on 40 CFR 136, data validation criteria, and method specific requirements, and are measured from date of collection. The holding time criteria depicted apply to all analyses necessary to successfully determine the contaminant level contained in the sample. Hence, the holding time criteria apply to any/all subsequent sample dilutions and re-analyses.

The TtNUS Project Manager for this project is Mr. Corey Rich and he must be contacted in the event of any laboratory problems that could impact project deadlines (i.e., late deliverables, technical problems in the lab that could lead to late deliverables.) To ensure good communication it is required that the laboratory's appointed project manager contact Mr. Rich once a week for the entire project duration.

Contact information for Mr. Rich is as follows:

Tetra Tech NUS, Inc.
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220
Phone: 412-921-8984
Fax: 412-921-4040
e-mail: corey.rich@tetratech.com

Analytical data turnaround times are to be measured from receipt of each sample shipment. All PDF analytical data package (2 CDs) and associated electronic (TXT) deliverables are due to the TtNUS Sample Management Coordinator, Ms. Tobrena Skeen, within the standard MSA turnaround term of 21 calendar days from receipt of the last sample in a Sample Delivery Group (SDG). Additionally all SDGs must contain 20 samples. The frequency in which SDGs contain less than 20 samples should be minimal. All PDF data packages and electronic deliverables must be received at the same time or the deliverable will be considered incomplete and payment deductions may be imposed. **Additionally the laboratory Project Manager must fax copies of chain of custody forms to Ms. Skeen as samples are received by the laboratory.**

Contact information for Ms. Skeen follows:

Tetra Tech NUS, Inc.
Foster Plaza 7
661 Andersen Drive
Pittsburgh, PA 15220
Phone: 412-921-8582
Fax: 412-921-4040
e-mail: tobrena.skeen@tetratech.com

4.0 PERIOD OF PERFORMANCE/BOTTLEWARE INFORMATION

All samples will be shipped to the laboratory via express carrier within 48-hours of collection. Please circle the Yes or No at the bottom of Table 1 which will indicate if the laboratory will provide courier service at no

extra charge. The first round of samples will be shipped to the laboratory **in the Fall of 2009 and the second round of samples will be shipped in the Spring of 2010**.

Shipment of bottleware to support the entire project will be coordinated at a later date.

The laboratory is to provide all necessary sample containers **(plus approximately 10% extra for breakage)**. All sample containers must meet ICHEM series 300 cleanliness criteria (or equivalent), and documentation of certified cleanliness must be provided. All of the appropriate sample bottleware must be pre-preserved. The bottleware must be shipped to the designated location in Coleman-like coolers. **The laboratory must also provide any extra coolers needed for return shipment of sample to the laboratory for analysis.** The laboratory is also requested to provide a packing slip indicating the analytical parameters for which each container type is designated, sample labels, and chain-of-custody forms. The laboratory is to dispatch proper bottleware for the collection of additional soil, per sampling location, for dry-weight determination.

The laboratory must provide Material Safety Data Sheets (MSDSs) for all preservatives sent with each bottleware shipment to the field. MSDSs must be representative of the chemicals provided as preservatives with regard to mixtures and/or purity of the chemicals. For example if a 35% sulfuric acid solution is the preservative, the MSDS provided should be for 35% sulfuric acid solution not 96% sulfuric acid.

5.0 ADDITIONAL COMMENTS/CONTACTS

Within a laboratory, internal transfers of samples, extracts, and digestates must be accomplished and documented as controlled custody transfers. The laboratory must maintain documentation that supports an unbroken chain of custody for samples, digestates and extracts from time of receipt or production in the laboratory until disposal.

The laboratory is to provide a minimum of 60 days storage of sample extracts and 60 days storage of intact sample aliquots, as stipulated in the MSA. **Additionally, the laboratory must store hardcopy and/or PDF data packages for 5 years.**

All analyses conducted under this subcontract assignment are to be performed at the solicited facility only. The laboratory is not permitted to lower-tier subcontract these analyses, or analyze these samples at a corporate facility other than the facility stipulated without prior notification and consent from the CLEAN Subcontracting Officer.

The unit cost for analysis is to include compensation for containers, preservatives, coolers, shipping costs, storage, disposal, and laboratory quality control analyses (such as matrix spike, matrix spike duplicate, laboratory duplicate, and laboratory control sample analyses.) These items are not to be billed as separate line items.

Technical, quality assurance, and data format concerns are to be directed to Ms. Kelly Carper at 412-921-7273 or via e-mail kelly.carper@tetratech.com. Ms. Carper must be contacted and informed of any difficulties encountered during the conduct of the requested analyses.

Questions regarding electronic diskette deliverable concerns are to be directed to Ms. Amy Thomson at 412-921-8182 or via e-mail amy.thomson@tetratech.com. Ms. Thomson must be

contacted and informed of any difficulties encountered preparing the required electronic deliverables.

Contract concerns, and response to this solicitation, are to be directed to:

Ms. Meg Price
CLEAN Subcontracting Officer
Tetra Tech NUS, Inc.
234 Mall Boulevard, Suite 260
King of Prussia, PA 19406
Phone: 610-491-9688
Fax: 610-491-9645
e-mail: meg.price@tetratech.com

Triplicate copies of invoices associated with the analyses contracted herein are to be submitted to the attention of the Accounting Supervisor:

Tetra Tech NUS, Inc.
661 Andersen Drive, Foster Plaza 7
Pittsburgh, PA 15220
Phone: 412-921-8506
Fax: 412-921-4040

Please confirm the laboratory's ability to perform the methodologies requested at the analyte detection limits indicated. Also confirm available laboratory capacity, and complete/confirm the costing information indicated in Table 1. **All costing information must reflect the terms and conditions established by the 2009 CLEAN MSA.**

TABLE 1
NUMBER OF SAMPLES/ANALYTICAL METHODS
NAVAL SUBMARINE BASE (NSB), NEW LONDON, CT
CTO WE24, PRE-DESIGN GROUNDWATER REMEDIATION SAMPLING

Matrix	Parameter	Method	# Samples	Unit Price	Total Cost
Aqueous	Total arsenic, copper, and lead	EPA 1640	40	$	$
	Dissolved arsenic, copper, and lead	EPA 1640	40	$	$

TOTAL COST $

Can the laboratory provide sample pick-up on site? YES or NO (circle one)
If yes is there an additional charge and what is that charge?_____
Name of Laboratory_____

Signature_____

ATTACHMENT A
Required Target Compound Lists and Quantitation Limits

Matrix: Aqueous
Analytical Group: Metals

Analyte	CAS Number	Project Action Limit (µg/L)	Project Action Limit Reference[1]	Project Quantitation Limit Goal (µg/L)	Laboratory	
					Quantitation Limit (µg/L)	Method Detection Limit (µg/L)
Arsenic	7440-38-2	10	Alt. CTDEP SWPC	3.33		
Copper	7440-50-8	48	Alt. CTDEP SWPC	16		
Lead	7439-92-1	13	CTDEP SWPC	4.33		

1 CTDEP SWPC: Connecticut Department of Environmental Protection, Surface Water Protection Criteria
Alt. CTDEP SWPC: Alternative CTDEP SWPC

ATTACHMENT B
Summary Form Requirements for PDF Deliverable and PDF Data Package Deliverables

PDF DATA PACKAGE DELIVERABLE REQUIREMENTS

The laboratory is to provide 2 compact disks (CDs) containing a PDF file in the following format:

1. Table of Contents
2. Case Narrative
3. Chain-of-Custody
4. Data Summary Package (contains summary of all CLP or CLP like Forms 1 through 15 per analytical fraction)
5. Analytical Fractions (VOA, SVOC, General Chemistry, etc.)
a. QC Summary (summary of all CLP or CLP like Forms 1 through 15 for a particular analytical fraction)
b. Raw Sample Data (includes all sample dilutions, sample re-analyses, QC samples, etc.)
c. Calibration Data (includes all initial and continuing calibrations)
d. Miscellaneous (includes extraction forms, IDLs, MDLs, etc.)

Each of the above sections should be bookmarked in the PDF for easy access.

Summary Form Requirements for PDF data package deliverable for non-CLP Methods:

The following summary forms are required as part of the data package deliverable for SW-846 6010 series for metals:

Results Report - must present all information presented on CLP FORM I.
Initial and Continuing Calibration Summary -must present all information presented on CLP FORM 2A.
CRDL Summary - must present all information presented on CLP FORM 2B.
Blanks - must present all information presented on CLP FORM 3.
ICP Interference Check Sample Summary - must present all information presented on CLP FORM 4.
Matrix Spike Summary - must present all information presented on CLP FORM 5A.
Post Digestion Spike - must present all information presented on CLP FORM 5B.
Lab Duplicate Results - must present all information presented on CLP FORM 6.
LCS Summary - must present all information presented on CLP FORM 7.
MSA Summary (Method of Standard Addition) - must present all information presented on CLP FORM 8.
ICP Serial Dilution Summary - must present all information presented on CLP FORM 9.
Detection Limits - must present all information presented on CLP FORM 10.
Linear range – must present all information presented on CLP FORM 12
Prep Log - must present all information presented on CLP FORM 13.
Analysis Run Log - must present all information presented on CLP FORM 14.
ICP-MS Tune – must present all information on CLP FORM 14 (ILM05.4)
ICP/MS Internal Standard Relative Intensity Summary - must present all information presented on CLP FORM 15 (ILM05.4).

<u>Also must include</u>: Instrument Calibration Records, Chain-of-Custody Forms, and Case Narrative.

ATTACHMENT C
ELECTRONIC DATA DELIVERABLE REQUIREMENTS

ELECTRONIC DATA FORMAT REQUIREMENTS

1.0 INTRODUCTION

The laboratory is to submit text-based tab delimited EDD files for each SDG using Tetra Tech's laboratory data checker explained below. The files must be in the format specified in this Attachment. Additional information such as laboratory name, project name, fractions included, project number, site name/number, laboratory contact person and any specific comments related to the EDD should be included in the comments section of the EDD Submittal page.

The RESULT for nondetects should be populated with the project-specific sample quantitation reporting limits (i.e., either the sample quantitation limit or method detection limit, as specified in Section 3.0 of this scope of work. Any corrections made to the hardcopy data must also be made to the electronic file. Appropriate qualifiers as identified by the analytical protocol must also be designated; laboratory QC non-compliance codes are not to be depicted.

Tetra Tech's electronic EDD format follows the ADAPT structure and requires the A1 and A3 files. The A2 file is only required if the project is using ADAPT; and, for non-ADAPT EDD submittals the A2 file may be omitted. The EDD consists of separate, tab-delimited ASCII text files. Each file corresponds to a database table. The tables are identified as the Analytical Results Table (A1) and Sample Analysis Table (A3). A separate set of text files must be created and submitted for each sample delivery group (SDG). The files must be identified to correspond to the (A1) table and the (A3) table. The file naming convention is: the Sample Delivery Group (SDG) followed by the table identifier (A1 or A3), followed by the ".txt" extension. The file names must not contain spaces or special characters. For example, the EDD file names for a laboratory-reporting batch identified as SDG001 would be as follows:

SDG001A1.txt
SDG001A3.txt

On certain projects Tetra Tech will utilize the ADAPT Electronic Data Validation software, which will require the laboratory to use the ADAPT electronic data deliverable checker software prior to submitting the files through Tetra Tech's laboratory data checker (this will be clearly specified in the Tetra Tech laboratory statement of work). The ADAPT checker software can be downloaded from Laboratory Data Consultants' web site: http://www.lab-data.com. For projects which Tetra Tech is using the ADAPT software, Tetra Tech will provide the laboratory with the project library. The laboratory is not permitted to modify the project library. ADAPT projects will require the laboratory to export all three checked files (A1, A2, and A3) from the ADAPT software and submit them through Tetra Tech's laboratory data checker. **ADAPT error logs generated must be included with the electronic PDF data validation package and cannot be submitted through the laboratory data checker.**

The values reported in the EDD text files must agree exactly with the final values reported on the PDF data package sample result summaries. The details of file naming conventions, data structure and data checker use are discussed below.

Analytical Results Table (A1 File)

The Analytical Results table contains analytical results and related information for target analytes in field samples and associated laboratory quality control samples (excluding calibrations and tunes). Field samples and laboratory method blanks must report a result record for each analyte reported within a method. Laboratory control samples (LCS and LCSD) and matrix spike samples (MS and MSD) must report a result record for every analyte specified as a spiked analyte in the laboratory statement of work. Table A1 in this document lists the field names and data type descriptions for the Analytical Results Table (A1).

Lab Instrument Table (A2 File)

A2 file is only required if the project is using ADAPT. In all other EDD submittals, the A2 file may be omitted. Laboratories should refer to the ADAPT User Guide for populating the A2 Table.

Sample Analysis Table (A3 File)

The Sample Analysis table contains information specific to field environmental samples and laboratory quality control analyses (excluding calibrations and tunes). A sample record must exist for each sample/method/matrix/analysis type combination. Table A3 in this document lists the field names and data type descriptions for the Sample Analysis Table (A3).

All electronic data deliverables are due within the same time established for the associated hardcopy data packages.

In addition, the laboratory QC officer must read and sign a copy of the Quality Assurance Review Form displayed on the next page of this Attachment. Electronic deliverables are not considered to be complete without the accompanying Quality Assurance Review Form.

I _____, as the designated Quality Assurance Officer, hereby attest that all electronic deliverables have been thoroughly reviewed and are in agreement with the associated hardcopy data. The enclosed electronic files have been reviewed for accuracy (including significant figures), completeness and format. The laboratory will be responsible for any labor time necessary to correct enclosed electronic deliverables that have been found to be in error. I can be reached at
(____)_____if there are any questions or problems with the enclosed electronic deliverables.

Signature:_____ Title: _____Date: _____

2.0 EDD Field Properties

Tables A1 and A3 in this document specify the EDD field properties. Laboratories should refer to the ADAPT User Guide for populating the A2 Table. These include the field name, sequence order, field description, data type/length and reporting requirement for each field. Fields in the EDD **must** be sequenced according to the order that they appear below in Tables A1 and A3. For example, in the Analytical Results table (A1), the field "ClientSampleID" will always be the first piece of information to start every new line of data (or database record), followed by the field "LabAnalysisRefMethodID", "AnalysisType", etc.

When creating an EDD as a text file, use the ASCII character set in a file of lines terminated by a carriage return and line feed. No extra characters are allowed at the end of a line, after the carriage return and line feed. Enclose each data value with double quotes (text qualifier) and separate each field value with a **tab** character (tab delimiter). Data fields with no information (null) may be represented by two consecutive tabs. For example, in the Sample Analysis table, since the "Collected", "ShippingBatchID", and "Temperature" fields do not apply to laboratory generated QA/QC samples, the record for a Laboratory Control Sample by Method 8270C would be entered as follows. Note that the first two fields ("ProjectNumber" and "ProjectName") are omitted in this example.

…"LCSW100598" "AQ" "LCSW100598" "LCS" "8270C",…etc.

If a field is populated with less than the maximum allowed number of characters, do not pad the values with leading or trailing spaces. In the above example, although the "MatrixID" field can accommodate up to 10 characters, only 2 characters were entered in this field. **Do not include the delimiter (tab character) within any of the field values.** Example EDD files may be downloaded from the LEDD Checker application.

An example database shall be sent for review prior to the first electronic deliverable in the required .txt format. The example file will be examined for completeness and comments will be sent to the laboratory. Any questions regarding the electronic deliverable should be directed to LabSupport@tetratech.com.

Table A1
Field Descriptions for the Analytical Results Table (Table A1)
Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ClientSampleID	Client or contractor's identifier for a field sample If a sample is analyzed as a laboratory duplicate, matrix spike, or matrix spike duplicate, append suffixes DUP, MS and MSD respectively to the Client Sample ID with no intervening spaces or hyphens (i.e. MW01DUP, MW01MS, and MW01MSD). For Method Blanks, LCS, and LCSD enter the unique LaboratorySampleID into this field. Do not append suffixes to the ClientSampleID for dilutions, reanalyses, or re-extracts (the AnalysisType field is used for this distinction). For example, MW01DL and MW01RE are not allowed. Parent sample records must exist for each MS and MSD. If an MS/MSD is shared between two EDDs, records for the MS/MSD and its parent sample must exist in the Analytical Results table for both EDDs.	Text	25	X
LabAnalysisRefMethodID	Laboratory reference method ID. The method ID may be an EPA Method number or a Lab Identifier for a method such as a SOP Number, however; method ID is specified by the project. The method ID must be entered into the standard list.	Text	25	X
AnalysisType	Defines the analysis type (i.e., Dilution, Reanalysis, etc.). This field provides distinction for sample result records when multiple analyses are submitted for the same sample, method, and matrix; for example dilutions, re-analyses, and re-extracts.	Text	10	X
LabSampleID	Laboratory tracking number for field samples and lab generated QC samples such as method blank, LCS, and LCSD. There are no restrictions for the LabSampleID except for field length and that the LabSampleID must be distinct for a given field sample or lab QC sample and method. Suffixes may be applied to the LabSampleID to designate dilutions, reanalysis, etc.	Text	25	X
LabID	Identification of the laboratory performing the analyses.	Text	7	X
ClientAnalyteID	CAS Number or unique client identifier for an analyte	Text	12	X

Table A1
Field Descriptions for the Analytical Results Table (Table A1)
Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	or isotope. If a CAS Number is not available, use a unique identifier provided by the client or contractor. The ClientAnalyteID for a particular target analyte or isotope should be specified by the project and must exist in the standard value tables for Analytes. For the LCS, LCSD, MS, and MSD, it is only necessary to report the compounds designated as spikes in the library (and surrogates for organic methods.) For TICs from GC/MS analyses, enter the retention time in decimal minutes as the Client Analyte ID.			
AnalyteName	Chemical name for the analyte or isotope. The project specifies how an analyte or isotope is named. The analyte name must be associated to a ClientAnalyteID in the standard values table for Analytes (excluding compounds designated as TIC's).	Text	60	X
Result	Result value for the analyte or isotope. Entries must be numeric. For non-detects of target analytes or isotopes and spikes, **do not enter "ND" or "0". Do not leave this field blank**. If an analyte or spike was not detected, enter the reporting limit value corrected for dilution and percent moisture as applicable. Do not enter "0"	Numeric (1)	20(6)	X
ResultUnits	The units defining how the values in the Result, DetectionLimit, and ReportingLimit fields are expressed. For radiochemistry this also includes how the value in the Error field is expressed.	Text	10	X
LabQualifiers	A string of single letter result qualifiers assigned by the lab based on client-defined rules and values. <u>The "U" Lab Qualifier must be entered for all non-detects.</u> Other pertinent lab qualifiers may be entered with the "U" qualifier. Order is insignificant. Lab qualifiers other than those listed in the standard	Text	7	Q

Table A1
Field Descriptions for the Analytical Results Table (Table A1)
Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	values table may be used. If so, these must be added to the standard value table in the application.			
DetectionLimit	For radiochemistry methods, the minimum detectable activity for the isotope being measured. For all other methods: The minimum detection limit value for the analyte being measured.	Numeric (1)	10(6)	X
DetectionLimitType	Specifies the type of detection limit (i.e., MDA, MDL, IDL, etc.).	Text	10	X
RetentionTime or Error	For radiochemistry methods only, enter the 2 Sigma Counting Errors. The units for error are entered in the ResultUnits field. For GC/MS methods only, enter the time expressed in decimal minutes between injection and detection for GC/MS TICs only For target analytes in all other methods, leave this field blank. Note: GC retention times are not evaluated at this time.	Text	5	T
AnalyteType	Defines the type of result, such as tracer, surrogate, spike, or target compound.	Text	7	X
PercentRecovery	For radiochemistry methods: The tracer yield, if applicable. For all other analytical methods: The percent recovery value of a spiked compound or surrogate. If the spike or surrogate was not recovered because of dilution, enter “DIL”. If a spike or surrogate was not recovered because of matrix interference, enter “INT”. If a spike or surrogate was not recovered because it was not added to the sample, enter “NS”.	Numeric (1)	5(3)	R
RelativePercentDifference	The relative percent difference (RPD) of two QC results, such as MS/MSD, LCS/LCSD, and Laboratory Duplicates. Report RPD in Laboratory Duplicate, LCSD, and MSD records only.	Numeric (1)	5(3)	D
ReportingLimit	Reporting limit value for the measured analyte or isotope Factor in the dilution factor and percent moisture correction, if applicable. The Reporting Limit for each analyte and matrix in a given method is specified in	Numeric (1)	10(6)	X

Table A1
Field Descriptions for the Analytical Results Table (Table A1)
Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	the project library or QAPP.			
ReportingLimitType	Specifies the type of reporting limit (i.e., CRQL, PQL, SQL, RDL, etc). The Reporting Limit Type for each method and matrix is specified in the project library or QAPP.	Text	10	X
ReportableResult	This field indicates whether or not the laboratory chooses an individual analyte or isotope result as reportable. Enter "YES" if the result is reportable. Enter "NO" if the result is not reportable. If only one analysis is submitted for a particular sample and method, enter "YES" for all target compounds (where Analyte Type = TRG). For GC/MS methods enter yes for tentatively identified compounds (where Analyte Type = TIC). If two or more analyses are submitted for a particular sample and method (i.e. initial analysis, reanalysis and/or dilutions), enter "YES" from only <u>one</u> of the analyses for each target compound. For example: a sample was run a second time at dilution because benzene exceeded the calibration range in the initial, undiluted analysis. All target analytes are reported in each analysis. For the initial analysis, (Analysis Type = RES), enter "NO" for benzene and enter "YES" for all other compounds. For the diluted analysis (Analysis Type = DL), enter "YES" for benzene and enter "NO" for all other compounds. For TICs (Analyte Type = TIC), if more than one analysis is submitted for a particular sample and method, choose only one of the analyses where Reportable Result = YES for <u>all</u> TICs. For example, a sample was run a second time because one or more target compounds exceeded the calibration range in the undiluted analysis. Choose a particular analysis and enter "YES" for all TICS. In the other analysis enter "NO" for all TICs. Note that it is not necessary to report the full target analyte list for the initial result, dilution, re-analysis, or re-extraction. However, each target analyte must be reported YES once and once only in the case of multiple analyses for a given sample, method, and matrix. In the case of organics, all surrogates must be reported for all analyses submitted for a given sample, method, and, matrix.	Text	3	X

Table A1
Field Descriptions for the Analytical Results Table (Table A1)
Contains laboratory test results and related information for field and QC samples (excluding instrument calibrations) on an analyte level for environmental chemistry including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
SpkConcnAdded	The spike added. This value must be reported in the same units as the result. Where (SA) in the following equation: % Recovery = (SSA-SC)/SA x 100% where : SSA is the spiked sample concentration (amount) after spiking. SC is the sample concentration (amount) before spiking. SA is the the expected increase in sample concentration (amount) as a result of spiking. This value must incorporate all correction factors such as dilution factor and moisture content that are applied to the spiked sample when computing the spiked sample concentration or amount.	Numeric (1)	10(6)	R
SpkParentSampleID	The sampleID of a sample (often called the original sample) that receives a spike aliquot to form a spiked sample such as a matrix spike. This is not the same as the ID of the spiked sample (such as a matrix spike) after spiking. The result for SpkParentSampleID and the result (i.e., SpkConcnAdded) for the spiked sample are used to compute percent recovery of the analyte.	Text	25	R
SamplePrepInitial	The initial sample preparation volume in liters (L) for aqueous samples or grams (g) for solid samples.	Numeric (1)	20(6)	
SamplePrepFinal	The final sample preparation volume in liters (L) for aqueous samples or grams (g) for solid samples.	Numeric (1)	20(6)	
Comment	Add any comments or additional information specific to the analyte test result data record.	Text	200	

X Required field.
Q Only required if laboratory has qualified the result.
T Only required for tentatively identified compounds by GC/MS.
R Only required if Analyte_Type =”SPK” or “SURR”.
D Only required for spiked compounds in the LCSD and MSD.
(1) Field Length indicates decimal precision in parenthesis. For example, 5(2) = a total width of 5 numbers including a maximum of 2 decimal places.

Table A3
Field Description for the Sample Analysis (Table A3)
This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
ProjectNumber	Project number assigned by the client.	Text	30	X
ProjectName	Project name assigned by the client.	Text	90	X
ClientSampleID	Client or contractor's identifier for a field sample If a sample is analyzed as a laboratory duplicate, matrix spike, or matrix spike duplicate, append suffixes DUP, MS and MSD respectively to the Client Sample ID with no intervening spaces or hyphens (i.e. MW01DUP, MW01MS, and MW01MSD). For Method Blanks, LCS, and LCSD enter the unique LaboratorySampleID into this field Do not append suffixes to the ClientSampleID for dilutions, reanalyses, or re-extracts (the Analysis_Type field is used for this distinction). For example, MW01DL and MW01RE are not allowed Parent sample records must exist for each MS and MSD. If an MS/MSD is shared between two EDDs, records for the MS/MSD and its parent sample must exist in the Sample Analysis table for both EDDs.	Text	25	X
Collected	Date and Time of sample collection. Refer to the date/time format at the end of this table. Leave this field blank for Method Blank, LCS, and LCSD	Date/ Time	16*	C
MatrixID	Sample matrix (i.e., AQ, SO, etc.)	Text	10	X
LabSampleID	Laboratory tracking number for field samples and lab generated QC samples such as method blank, LCS, and LCSD. There are no restrictions for the LabSampleID except field length and that the LabSampleID must be unique for a given field sample or lab QC sample and method.	Text	25	X
QCType	This record identifies the type of quality control sample QC (i.e., Duplicate, LCS, Method Blank, MS, or MSD). For regular environmental samples, populate this field with "NM".	Text	10	X
ShippingBatchID	Unique identifier assigned to a cooler or shipping container used to transport client or field samples. Links all samples to a cooler or shipping container. No	Text	25	C

Table A3
Field Description for the Sample Analysis (Table A3)
This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	value is required for method blanks, LCS, and LCSD.			
Temperature	Temperature (in centigrade degrees) of the sample as received. This field is not required for radiochemistry methods.	Numeric (1)	10(6)	C
LabAnalysisRefMethodID	Laboratory reference method ID. The method ID may be an EPA Method number or laboratory identifier for a method such as a SOP number, however; values used for Laboratory Method IDs are specified by the project and must in the in standard value list for method IDs.	Text	25	X
PreparationType	Preparation Method Number (i.e., 3010A, 3510C, 3550C, 5030B, etc.) For analytical procedures that do not have a specific preparation method number, use “Gen Prep”.	Text	25	X
AnalysisType	Defines the type of analysis such as initial analysis, dilution, re-analysis, etc. This field provides distinction for sample records when multiple analyses are submitted for the same sample, method, and matrix, for example: dilutions, re-analyses, and re-extracts.	Text	10	X
Prepared	For radiochemistry leave this field blank. For all other methods enter the date and time of sample preparation or extraction. Refer to the date/time format at the end of this table.	Date/ Time	16*	X
Analyzed	Date and time of sample analysis. Refer to the date and time format at the end of this table.	Date/ Time	16*	X
LabID	Identification of the laboratory performing the analysis.	Text	7	X
QCLevel	The level of laboratory QC associated with the analysis reported in the EDD. If only the Analytical Results Table (A1) and the Sample Analysis Table (A3) information are submitted for the sample, enter “COA”. If the Laboratory Instrument Table (A2) information is also submitted for the sample, enter “COCAL”	Text	6	X
ResultBasis	Indicates whether results associated with this sample records are reported as wet or percent moisture corrected. This field is only required for soils and sediments. Enter “WET” if results are not corrected for	Text	3	X

Table A3
Field Description for the Sample Analysis (Table A3)
This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	percent moisture. Enter "DRY" if percent moisture correction is applied to results.			
TotalOrDissolved	This field indicates if the results related to this sample record are reported as a total or dissolved fraction. This field is only required for metal methods. For all other methods leave this field blank.	Text	3	X
Dilution	Dilution of the sample aliquot. Enter "1" for method blanks, LCS, and LCSD, or if the field samples was analyzed without dilution.	Numeric (1)	10(6)	X
HandlingType	Indicates the type of leaching procedure, if applicable (i.e., SPLP, TCLP, WET). Leave this field blank if the sample analysis was not performed on a leachate.	Text	10	L
HandlingBatch	Unique laboratory identifier for a batch of samples prepared together in a leaching procedure (i.e., SPLP, TCLP, or WET preparation). The HandlingBatch links samples with leaching blanks. Leave this field blank if the sample analysis was not performed on a leachate	Text	12	L
LeachateDate	Date and time of leaching procedure (i.e., date for SPLP, TCLP, or WET preparation). Refer to the date and time format at the end of this table. Leave this field blank if the sample analysis was not performed on a leachate	Date /Time	16*	L
Percent_Moisture	Percent of sample composed of water. Enter for soil and sediment samples only.	Numeric (1)	10(6)	X
MethodBatch	Unique laboratory identifier for a batch of samples of similar matrices analyzed by one method and treated as a group for matrix spike, matrix spike duplicate, or laboratory duplicate association The method batch links the matrix spike and/or matrix spike duplicate or laboratory duplicates to associated samples. Note the MethodBatch association may coincide with the PreparationBatch association. The MethodBatch is specifically used to link the MS/MSD and/or DUP to associated samples.	Text	12	X
PreparationBatch	Unique laboratory identifier for a batch of samples	Text	12	X

Table A3
Field Description for the Sample Analysis (Table A3)
This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	prepared together for analysis by one method and treated as a group for method blank, LCS and LCSD association. The PreparationBatch links method blanks and laboratory control samples (blank spikes) to associated samples. Note, the PreparationBatch association may coincide with the MethodBatch association but the PreparationBatch specifically links the Method Blank and LCS to associated samples.			
RunBatch	For radiochemistry methods leave this field blank. For all other methods the RunBatch is the unique identifier for a batch of analyses performed on one instrument under the control of one initial calibration and initial calibration verification. The RunBatch links both the initial calibration and initial calibration verification to subsequently analyzed and associated continuing calibrations, field samples, and QC analyses. For GC/MS methods, the RunBatch also links a BFB or DFTPP tune. A distinct RunBatch must used with every new initial calibration within a method The value entered in this field links a particular sample/method/analysis type record to a set of associated initial calibration and initial calibration verification records from Table A2. This field is only required if the A2 table is included with the EDD.	Text	12	X
AnalysisBatch	For radiochemistry methods leave this field blank. For all other methods the AnalysisBatch is the unique identifier for a batch of analyses performed on one instrument and under the control of a continuing calibration or continuing calibration verification. The AnalysisBatch links the continuing calibration or calibration verification to subsequently analyzed and associated field sample and QC analyses. For GC/MS methods, the AnalysisBatch also links the BFB or DFTPP tune. A distinct AnalysisBatch must be used with every new continuing calibration or continuing calibration verification within a method The value entered in this field links a particular sample/method/analysis type record to a set of associated continuing calibration records in the Laboratory Instrument table.	Text	12	X

Table A3
Field Description for the Sample Analysis (Table A3)
This table contains information related to analyses of field samples and laboratory QC samples (excluding calibrations and tunes) on a sample level for environmental chemical analyses including radiochemistry

Field Name	Field Name Description	Field Type	Field Length	Required Value
	This field is only required if the A2 table is included with the EDD.			
LabReportingBatch	Unique laboratory identifier for the EDD. This is equivalent to the sample delivery group, lab work number, login ID, etc. The LabReportingBatch links all records in the EDD reported as one group. The value entered in this field must be the same in all records.	Text	12	X
LabReceipt	Date and time the sample was received in the lab. A time value of 00:00 may be entered. Refer to the date/time format at the end of this table.	Date/ Time	16*	X
LabReported	Date and time hard copy reported delivered by the lab. A time value of 00:00 may be entered. Refer to the date/time format at the end of this table.	Date/ Time	16*	X
Comment	Add any comments or additional information specific to the sample analysis data record.	Text	200	

C Only required for regular samples, duplicates and MS/MSDs.
L Only required if analysis performed is SPLP, TCLP or WET extracts.
X Required field.
(1) Field Length indicates decimal precision in parenthesis. For example, 5(2) = a total width of 5 numbers including a maximum of 2 decimal places.
* Format Date and Time as MM/DD/YYYY hh:mm; where MM = two digit month, DD = two digit day, and YYYY = four digit year, hh = hour in 24 hour format, and mm = minutes.

3.0 Laboratory Data Checker

The Laboratory Data Checker is a web-based application that will review Laboratory Electronic Data Deliverables (LEDDs) for adherence to Tetra Tech's EDD format requirements. EDDs will be reviewed for elements such as missing data and/or columns of data, and compliance of the data within each column to the required data types/lengths. Once an EDD passes through the checker with no errors, it must be submitted to Tetra Tech through the LEDD Checker application.

Access to the LEDD Checker application will be provided by an initial registration/approval process. An Information Systems Group (ISG) Administrator will approve requests for access**.** To access the site or begin the registration process, visit the ISG web site at http://isg.ttnus.com and select the "Laboratory Checker" link on the left of the home page. Registered users may access the checker immediately by logging in to the system using theircredentials. New users must select the "Register" button and provide all of the requested information**.**

After completing all fields on the registration form, select the "Submit" button to complete the request process. Upon verification by an ISG Administrator, an email notification will be sent verifying the user ID, password and account status. Forgotten passwords may be retrieved by using the "Forgot password?" link on the login page. Note that the email address that was provided for registration or password retrieval is the user ID and must be a valid e-mail address.

The general process for submitting EDD files through the LEDD Checker involves a 3-stage process that includes an upload stage, an error checking stage and a submittal stage.

Log into the LEDD Checker by typing your login credentials and select the "Login" button. The LEDD Checker home page provides a general overview of the checker functionality and EDD file format requirements. At the bottom of the home page, example EDDs are provided that may be viewed or downloaded. To download the files, right click on the link and select "Save target as" from the menu. Each LEDD Checker page includes a navigation bar with links to return to the home page or continue the checking and submittal process. Users should **NOT** use the back or forward buttons on the browser, instead use the links provided in the application to navigate through the site.

Detailed information regarding EDD preparation, formatting requirements and text file naming conventions are provided in the Electronic Data Format Requirements Section of the Laboratory SOW.

Begin the upload stage by selecting the "Upload/Check Files" link on the home page. Follow the steps on the upload page starting with the selection of the laboratory name that corresponds to your organization. If your organization is not listed, contact LabSupport@tetratech.com, and provide a full description of your organization name, contact information and include "Laboratory Contractor ID Request" in the subject line. An ISG Administrator will respond to the request via e-mail.

Load the appropriate A1, A2, or A3 target EDD files by clicking the "Browse" button next to each data table input box. A file browser dialog will appear allowing files to be selected from a local or network drive. After the EDD files are loaded, click the "Upload" button to complete the upload stage. Note that each table may be uploaded and checked separately; however, a minimum of the A1 and A3 files are required in order to submit the EDDs.

If the file upload was successful, the checking page will immediately load. Begin the checking stage by selecting the "Check Files" button. The LEDD Checker will begin validating the EDD files for compliance. Depending on file size and network activity the validation process may take several minutes. The progress should be displayed in the information bar at the bottom of the browser window. **Do not** select the "Check Files" button again or otherwise use the browser during this process. Other applications may be used; however, note that the LEDD Checker may not sit idle for more than 30 minutes. If the time is exceeded a new session must be started in a new browser window.

Any errors will be processed and returned on the error page. The following general errors may be returned.

- Column count / table structure errors – due to column header names being included, improper delimiter, extra tabs, extra or missing columns of data, spaces or other characters at the end of a row.
- Row and column value specific errors – may occur for one or more reasons including: data truncation, invalid date / time format, invalid decimal precision or field width exceedance, or if a value is not in a list of valid values or expected range.

If column count / table structure errors are encountered, the LEDD Checker will return an error and stop the checking process.

The EDDs will not be processed any further until the column errors are resolved. Text fields are validated for truncation. Date / Time fields are validated for truncation and format compliance. Numeric decimal fields are validated for truncation, character type compliance and decimal precision. All required fields are validated for null values or empty text strings (i.e. spaces). The LEDD Checker will return a list of all errors in and include a reference to the row number on which the error occurred. Note that consecutive EDD files may be loaded and checked, and submitted while logged in. However, no data may be submitted until all EDD files have passed through the LEDD Checker without errors. The list of errors may be printed by selecting the "Print this Page" button from the checker error page.

If the EDD files pass with no errors, the submittal page will immediately load. To complete the submittal stage, include the following information in the comment and additional information area of the form: laboratory name, laboratory contact person, project name, project number, site name/number, fractions included and any specific comments related to the EDD. Select the “Submit Files” button to continue the submittal process.

The submittal stage is not considered complete until a unique ticket key reference is returned in the browser window. The ticket key reference must be printed for record of submission and future reference. In addition, a copy of the ticket key reference must be included in the PDF data package.

APPENDIX D

LABORATORY STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE

for

DETERMINATION OF METALS AND TRACE ELEMENTS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY (ICP-MS); EPA METHOD 6020

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SOP No.: MET-6020

Revision: 13

June 26, 2009

Approved by: _____ Supervisor _____ Date 7/6/09

_____ QA Manager _____ Date 7/6/09

_____ Laboratory Manager _____ Date 7/6/09

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Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date: _____

DETERMINATION OF METALS AND TRACE ELEMENTS BY INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY (ICP-MS) EPA METHOD 6020

1 SCOPE AND APPLICATION

1.1 This procedure is used to determine the concentrations of certain elements in water, soil, tissues, aqueous and non-aqueous wastes, and sediment samples using EPA Method 6020 or 6020A. Table 1 indicates analytes that are typically determined by this procedure and lists the standard Method Reporting Limits (MRLs) for each analyte in water and soil. Equivalent nomenclature for MRL includes Estimated Quantitation Limit (EQL) and Practical Quantitation Limit (PQL). Therefore, MRL=EQL=PQL. Project-specific MRLs may apply, and if lower than standard MRLs, it is demonstrated through method detection limit determinations and analysis of MRL standards that the MRL is achievable. Method Detection Limits (MDLs) that have been achieved are listed in Table 1. These may change as annual studies are performed.

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1.2 The complexity of the technique generally requires outside study of appropriate literature as well as specialized training by a qualified spectroscopist. The scope of this document does not allow for the in-depth descriptions of the relevant spectroscopic principles required for gaining a complete level of competence in this scientific discipline.

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2 SUMMARY OF METHOD

2.1 Prior to analysis, samples must be digested using appropriate sample preparation methods. The digestate is analyzed for the elements of interest using ICP-mass spectrometry (ICP-MS).

2.2 Methods 6020 and 6020A describe the multi-elemental determination of analytes by ICP-MS. The method measures ions produced by a radio-frequency inductively coupled plasma. Analyte species originating in a liquid are nebulized and the resulting aerosol transported by argon gas into the plasma torch. The ions produced are entrained in the plasma gas and introduced, by means of an interface, into a mass spectrometer. The ions produced in the plasma are sorted according to their mass-to-charge ratios and quantified with a channel electron multiplier. Interferences must be assessed and valid corrections applied or the data flagged to indicate problems. Interference correction must include compensation for background ions contributed by the plasma gas, reagents, and constituents of the sample matrix.

3 DEFINITIONS

3.1 **Analysis Sequence** - Samples are analyzed in a set referred to as an analysis sequence. The sequence begins with instrument calibration followed by sample digestates interspersed with calibration standards.

3.2 **Independent Calibration Verification (ICV)** - ICV solutions are made from a stock solution which is different from the stock used to prepare calibration standards and is used to verify the validity of the standardization.

3.3 **Matrix Spike** (MS) - In the matrix spike analysis, predetermined quantities of standard solutions of certain analytes is added to a sample matrix prior to sample digestion and analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for each of the analytes detected.

3.4 **Matrix Spike Duplicate** (MSD) - In the matrix spike duplicate analysis, predetermined quantities of standard solutions of certain analytes are added to a sample matrix prior to sample digestion and analysis. The purpose of the matrix spike duplicate is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for each of the analytes detected. The relative percent difference between the matrix spikes is calculated and used to assess analytical precision.

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3.5 **Duplicate Sample** (DUP) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.6 **Method Blank** - The method blank is an artificial sample designed to monitor introduction of artifacts into the process. The method blank is carried through the entire procedure.

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3.7 **Continuing Calibration Verification Standard (CCV)** - A standard analyzed at specified intervals and used to verify the ongoing validity of the instrument calibration.

3.8 **Instrument Blank (CCB)** - The instrument blank (also called continuing calibration blank) is a volume of blank reagent of composition identical to the digestates. The purpose of the CCB is to determine the levels of contamination associated with the instrumental analysis.

4 INTERFERENCES

4.1 Isobaric elemental interferences in ICP-MS are caused by isotopes of different elements forming atomic ions with the same nominal mass-to-charge ratio (m/z). A data system must be used to correct for these interferences. This involves determining the signal for another isotope of the interfering element and subtracting the appropriate signal from the analyte isotope signal. Attention should be given to circumstances where very high ion currents at adjacent masses may contribute to ion signals at the mass of interest. Matrices exhibiting a significant problem of this type may require resolution improvement, matrix separation, or analysis using another isoptope.

4.2 Isobaric molecular and doubly-charged ion interferences in ICP-MS are caused by ions consisting of more than one atom or charge, respectively. Most isobaric interferences that could affect ICP-MS determinations have been identified in the literature. Refer to Method 6020/A for further discussion.

5 SAFETY

5.1 All appropriate safety precautions for handling solvents, reagents and samples must be taken when performing this procedure. This includes the use of personnel protective equipment, such as, safety glasses, lab coat and the correct gloves.

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5.2 Chemicals, reagents and standards must be handled as described in the CAS safety policies, approved methods and in MSDSs where available. Refer to the CAS Environmental, Health and Safety Manual and the appropriate MSDS prior to beginning this method.

5.3 Hydrochloric and/or Nitric Acid are used in this method. These acids are extremely corrosive and care must be taken while handling them. A face shield should be used while pouring acids. And safety glasses should be worn while working with the solutions. Lab coat and gloves should always be worn while working with these solutions.

5.4 High Voltage - The RF generator supplies up to 2000 watts to maintain an ICP. The power is transferred through the load coil located in the torch box. Contact with the load coil while generator is in operation will likely result in death. When performing maintenance on the RF generator, appropriate grounding of all HV capacitors must be performed as per manufacturer.

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5.5 UV Light - The plasma is an intense source of UV emission, and must not be viewed with the naked eye. Protective lenses are in place on the instrument. Glasses with special protective lenses are available when direct viewing of the plasma is necessary.

6 SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1 Aqueous samples are typically collected in plastic containers. Aqueous samples are preserved with nitric acid (pH<2), then refrigerated at 4 ± 2°C from receipt until digestion. Soil or solid samples may be collected in plastic or glass jars. Non-aqueous samples are refrigerated at 4 ± 2°C from receipt until digestion.

6.2 Samples are prepared via procedures in SOPs MET-DIG, MET-3020, or MET-3050 depending on matrix and project specifications. Samples are generally received in the ICP-MS laboratory as 1-15% Nitric Acid digestates. Digestates originating from soil samples with greater than 60% solids are diluted prior to instrumental analysis by a factor of 5. This allows the analysis to achieve maximum sensitivity which results in optimum MRLs.

6.3 Digestates are stored in the appropriate volumetric containers. Following analysis, digestates are stored until all results have been reviewed. Digestates are neutralized prior to disposal through the sewer system, 2 weeks after data is reviewed.

7 APPARATUS & EQUIPMENT

7.1 Instruments: Thermo Elemental ExCell (K-ICP-MS-02) Serial # EX191, and Thermo Elemental X-Series (K-ICP-MS-03) Serial # X0193.

7.2 Thermo Meinhard type (Part # 1201318)

7.3 Thermo Impact Bead Quartz Spray Chamber (Part # 3600170)

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7.4 Thermo X7 Nickel Sample Cone (1.0 mm orifice) (Part # 3004661), or Xi sample cone (part # 3600812)

7.5 Thermo X7 Nickel Skimmer Cone (0.75 mm orifice) (Part # 3200860) or Xi skimmer cone(part # 3600811)

8 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

8.1 All standards are prepared from NIST traceable standards. The expiration dates are assigned according to the EPA method and the vendor's assigned expiration dates. For example, working ICS solutions are prepared weekly in accordance with Method 6020, Section 5.6.1.

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8.1.1 1000 ppm Single Element Stock Standard Solutions: Each stock standard is store at room temperature on shelves located in room 113 of the metals lab. The manufacturer, lot number, and expiration date of each stock standard is recorded in a bound logbook also located in room 113. Additionally each stock standard is given a unique, identifying name.

8.1.2 Intermediate Standard Solutions: Intermediate mixed stock solutions are made from the individual stock standards described above. The individual component of each mixed solution is recorded in a bound logbook located in the ICP-MS laboratory and mixed solution is given a unique, identifying name. The expiration date for the intermediate standard is the earliest of any one of its stock components.

8.1.3 Calibration Standards: Calibration standards are made fresh daily from the intermediate standard solutions. Each individual intermediate standard used in the calibration standard is recorded in a bound logbook located in the ICP-MS laboratory, and the calibration standard solution is given a unique, identifying name. The calibration standards unique name is used on the raw data to link the data to the subsequent prepared standards and ultimately the original purchased stock standard.

8.2 Standards Preparation

8.2.1 Expiration of all standard solutions defaults to the earliest expiration date of an individual component unless otherwise specified.

8.2.2 Calibration Standards

The calibration standard is prepared from two intermediate stock solutions. These solutions are prepared in acid rinsed 1000 mL Class A volumetric flasks following the formulations laid out on the attached example standard sheet (see Attachments). The working calibration standard is made daily by aliquoting 2.5 mL of each of the intermediate solutions in to a 100 mL Class A volumetric flask and diluting to volume with 1% HNO3. This standard is also used as the Continuing Calibration Verification (CCV).

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8.2.3 Initial Calibration Verification (ICV)

8.2.3.1 The ICV intermediate stock solution is prepared in an acid rinsed 100 mL Class A volumetric flask. The solution is prepared by adding 2.0 mL of Inorganic Ventures QCP-CICV-1, 1.0 mL each of QCP-CICV-2 and QCP-CICV-3, 0.5 mL of 1000 ppm Molybdenum stock solution, 0.5 mL of 1000 ppm Uranium stock solution and diluting to volume with 1% HNO3.

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8.2.3.2 The working ICV solution is prepared by aliquoting 0.5 mL of the mixed ICV intermediate solution into an acid rinsed 100 mL Class A volumetric flask and diluting to volume with 1% HNO3.

NOTE: The ICV solution is not at the midpoint of the linear range which may be as high as 1000 µg/L for some elements. The ICV solution used is a premixed standard purchased from Inorganic Ventures and contains the elements of interest between 2.5 and 100 µg/L. This solution provides calibration confirmation at more representative levels, given that most ICP-MS analyses are quantifying analytes in the low-ppb to sub-ppb range.

8.2.4 Interference Check Solutions (ICSA and ICSAB)

8.2.4.1 The ICSA is prepared in an acid rinsed 50 mL Class B volumetric flask by aliquoting 1.0 mL of Elements ICSAm (CS-CAK02) solution and diluting to volume with 1% HNO3.

8.2.4.2 The ICSAB is prepared in an acid rinsed 50 mL Class B volumetric flask by aliquoting 1.0 mL of Elements ICSAm (CS-CAK02), 0.125 mL of Inorganic Ventures 6020ICS-9B, and 0.250 mL of 10 ppm Molybdenum solutions and diluting to volume with 1% HNO3.

8.2.5 Post-digestion spikes are performed by adding appropriate amounts of the calibration intermediate solutions to aliquots of the sample digestate. The volumes of each standard used vary based on the native concentrations found in the field samples. Refer to the post-digestion spike in Section 12 for details.

8.2.6 Refer to the appropriate digestion SOP for details of LCSW and matrix spike solution composition and preparation.

8.2.7 Tuning / Mass Calibration Solution

8.2.7.1 A 10 ppm intermediate solution containing Ba, Be, Bi, Co, In, Li, Pb, Mg, Tl, and U is prepared by adding 10 mL of each from 1000 ppm stock standards to an acid rinsed 1000 mL volumetric flask and diluting to volume with 1% nitric acid. The expiration date for the intermediate solution is the earliest of any one of its stock components.

8.2.7.2 The working solution is prepared in two ways. For the ExCell (K-ICP-MS-02) a 1.0 ppb tune/mass calibration solution is prepared by adding 0.10 mL of intermediate solution to an acid rinsed 1000 mL volumetric flask and diluting to volume with 1% nitric acid. For the X-Series (K-ICP-MS-03) instrument a 5.0 ppb tune/mass calibration solution is prepared by adding 0.50 mL of intermediate solution to an acid rinsed 1000 mL volumetric flask and diluting to volume with 1% nitric acid. The expiration date for this solution is taken from the intermediate stock above.

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8.3 Internal Standards Stock Solution – Prepare a 10 µg/mL solution containing ^{71}Ga, ^{115}In, ^{6}Li, ^{175}Lu, ^{103}Rh ^{45}Sc, and ^{89}Y by adding 10.0 mL of each 1000 ppm single element stock solution to a acid rinsed 1000 mL volumetric flask and diluting to volume with 1% nitric. Use this solution for addition to blanks, calibration standards and samples at a ration of 0.5 mL of internal standard to 100 mL of solution, or dilute by an appropriate amount using 1% (v/v) nitric acid, if the internal standards are being added by peristaltic pump.

8.4 Additional Reagents

8.4.1 Reagent water, ASTM Type II

8.4.2 "OmniTrace Ultra" Concentrated Nitric Acid (EM Science # NX0408-2)

8.4.3 Argon (Airgas Industrial Grade – 99.999% pure, bulk delivered)

9 PREVENTIVE MAINTENANCE

9.1 All maintenance is documented in the instrument logbook. CAS/Kelso maintains a service contract with the instrument manufacturer that allows for an unlimited number of service calls and full reimbursement of all parts and labor.

9.2 Most routine maintenance and troubleshooting is performed by CAS staff. Preventive maintenance activities listed below should be performed when needed as determined by instrument performance (i.e. stability, sensitivity, etc.) or by visual inspection. Other maintenance or repairs may, or may not require factory service, depending on the nature of the task.

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- cone removal and cleaning
- removal and cleaning of ICP glassware and fittings
- checking and cleaning RF contact strips
- checking air filters and cleaning if necessary
- checking the oil mist filters and cleaning if necessary
- checking the rotary pump oil and adding or changing if necessary
- removal and cleaning of extraction lens
- removal and cleaning of ion lens stack
- replace the electron multiplier as necessary

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10 RESPONSIBILITIES

10.1 It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. This demonstration is in accordance with the training program of the laboratory. Final review and sign-off of the data is performed by the department supervisor/manager or designee.

10.2 It is the responsibility of the department supervisor/manager to document analyst training. Documenting method proficiency, as described in the SOP for Documentation of Training, is also the responsibility of the department supervisor/manager.

11 PROCEDURE

11.1 Refer to method 6020 (or 6020A) and the instrument manuals for detailed instruction on implementation of the following daily procedures preceding an analytical run.

11.2 After the instrument has been placed in the "Operate" mode, begin completing the daily instrument log (see Attachments). Refer to the instrument manuals for the optimum settings for each instrument.

11.3 The following parameters are monitored to assure awareness of changes in the instrumentation that serve as signals that optimum performance is not being achieved, or as indicators of the physical condition of certain consumable components (i.e. EMT and cones).

11.3.1 Multiplier Voltages

11.3.2 Gas Flows - Coolant Ar

11.3.3 The nebulizer and auxiliary flows are adjusted later as part of the optimizing procedure.

11.4 Optimization

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11.4.1 Gas Flows

11.4.1.1 Allow a period of not less than 30 minutes for the instrument to warm up.

11.4.1.2 Aspirate a mixed tune solution into the plasma and monitor the instrument output signal of In at mass 115 on the ratemeter. Adjust the nebulizer and auxiliary flows to obtain maximum signal. Adjust the tension screw on the peristaltic pump to obtain minimum noise in the analytical signal. Record flow rates and note any large variances.

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Note: Significant differences in flow rates will be observed for different torches and cones.

11.4.2 Tuning

11.4.2.1 Ion Lens Setting - While monitoring the output signal of a mixed tune solution at mass 115 on the ratemeter, adjust the ion lenses to obtain maximum sensitivity. Refer to the instrument manual for details on performing the adjustments.

11.4.2.2 Mass Calibration - Aspirate the tune / mass calibration solution described in section 9.2.7.2 and perform the mass calibration using the instrument's Mass Calibration program. (Refer to the instrument manual for details pertaining to the mass calibration procedure.) The acceptance criteria for the mass calibration is <0.1 amu from the true value. If the mass calibration fails criteria re-tune the instrument and perform the mass calibration procedure again.

11.4.2.3 Resolution Check - Using the spectra created during the mass calibration procedure; perform the resolution check to assure the resolution is less than 0.9 AMU at 10% peak height. If the resolution does not pass criteria adjust the instrument's resolution settings, run a new scan of the mass calibration solution and recheck.

11.4.2.4 Stability Check - Using the tune / mass calibration solution, perform a short-term stability check as per EPA Method 6020 or 6020A. The relative standard deviations of five scans for each element in the tune solution must be < 5%. If the test does not pass criteria determine the cause (i.e. dirty cones, improper tune, etc.) correct the problem and re-run the test.

11.5 Analytical Run

11.5.1 Calibrate the instrument using a calibration blank (Standard 0), composed of reagent water and 1% nitric acid, and the working calibration standard (8.2.2). The masses typically monitored and those used for quantification are listed in Table 1. These masses are set as defaults in the instrument's analytical procedures. To begin select the correct method. Nebulize Standard 0 (Blank) into the plasma. Allow 1-2 minutes for system to equilibrate prior to establishing baseline. Follow directions on computer screen to perform standardization. Nebulize the working calibration standard into the plasma. The operator must sign and date the first page of standardization.

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11.5.2 After the first CCB and before the ICS standards a CRA (MRL) standard is analyzed. For methods other than 6020A the acceptance criteria are a detected result of ± 100%. For 6020A, the criteria are 70-130% recovery. For DoD projects, the CRA criteria are 80-120%.

Note: For 6020A the CRA must also be analyzed at the end on the analytical run sequence.

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11.5.3 Perform the analysis in the order listed below. A daily run log of all samples analyzed is maintained.

Initial Calibration Verification (ICV)
Continuing Calibration Verification (CCV)
Initial Calibration Blank (ICB)
Continuing Calibration Blank (CCB)
CRA
ICSA
ICSAB
Analyze 7 Samples
CCV
CCB
Analyze 10 Samples
CCV
CCB
Repeat sequence as required to complete analytical run, analyzing CCVs/CCBs every 10 analyses and at the end of the run.

12 QA/QC REQUIREMENTS

12.1 Initial Precision and Recovery Validation

The accuracy and precision of the procedure must be validated before analysis of samples begins, or whenever significant changes to the procedures have been made. To do this, four LCS aliquots are prepared and analyzed. The average percent recovery of for each analyte must be 85-115% (for water, and within the LCS limits for soils) and the RSD <20%.

12.2 Method Detection Limits

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12.2.1 A method detection limit (MDL) study must be undertaken before analysis of samples can begin. To establish detection limits that are precise and accurate, the analyst must perform the following procedure. Spike a minimum of seven blank matrices at a level near or below the MRL. Follow the procedures starting in Section 11 to analyze the samples. Refer to the CAS SOP for *The Determination of Method Detection Limits and Limits of Detection* details of performing the MDL study.

12.2.2 Calculate the average concentration found (x) and the standard deviation of the concentrations for each analyte. Calculate the MDL for each analyte using the correct T value for the number of replicates. MDL's must be performed annually or whenever there is a significant change in the background or instrument response.

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12.3 For method 6020A, an LLQC sample (a CRA that is carried through the digestion) must be analyzed to verify accuracy at the MRL. The recovery must be 70-130%.

12.4 Instrument Detection Limits (IDLs) and linear ranges studies are performed quarterly. These will be calculated and made available to the ICP-MS operator. Linear range studies determine the Linear Dynamic Range (LDR) of the each instrument by analysis of a high concentration standard with results with ± 10% of the expected value. For non-DoD projects samples may be quantified between the MRL and 90% of the LDR without flagging. The Linear Calibration Range (LCR) is established by the highest calibration standard.

- **Note:** IDLs must be < LOD for DOD projects. DoD project samples with concentrations above the calibration standard must be diluted to bring results within the quantitation range. The LOQ and cal standard establish the quantitation range. The lab may report a sample result above quantitation range if the lab runs and passes a CCV that is > sample result.

12.5 The Initial Calibration Verification (ICV) standard is analyzed immediately after calibration. The results of the ICV must agree within ±10% of the expected value. If the control limits are exceeded, the problem will be identified and the instrument recalibrated.

12.6 A Continuing Calibration Verification (CCV) and Continuing Calibration Blank (CCB) are analyzed after calibration then every 10 samples thereafter with a final CCV/CCB closing the final samples of the analytical run.

12.6.1 The results of the CCV must agree within ±10% of the expected value.

12.6.2 The CCB measured values must be less than the MRL for each element for standard applications. Other project-specific criteria may apply (for DoD QSM projects CCB can have no analytes > the LOD).

12.6.3 If the control limits are exceeded, the problem will be identified and corrective action taken. The instrument recalibrated. The previous 10 samples must be reanalyzed.

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NOTE: Section 8.8.4 of method 6020A states that the CCB must be controlled to <3 times the IDL. The IDL, which are calculated from the analysis of reagent blanks, are in most cases too low to be used as a CCB control criteria when routinely analyzing environmental samples. The effects of sample matrices on the baseline values can be significant in relation to the IDLs. The CCBs are controlled to the MRL (thus minimizing any negative impact on the data) and in cases where the CCB value is greater than the MRL the effected data is evaluated for usability (i.e. are the sample levels greater than 20 times the level in the CCB.).

12.7 The ICSA and ICSAB solutions are analyzed after calibration and before any field samples. The solutions are then reanalyzed every 12 hours. Results of the ICSA are used by the analyst to identify the impact of potential interferences on the quality of the data. Based on these results appropriate action should be taken when interferences are suspected in an field sample including, but not limited to, selecting and alternative isotope for quantification, manual correction of the data, elevating the MRL, selection of an alternative method (e.g. optical ICP, GFAA) or flagging the result as estimated when no other action is possible. Results for the spiked analytes in the ICSAB solution must agree with ± 20% of the expected value.

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INTERFERENCE CHECK SAMPLE COMPONENTS AND CONCENTRATIONS

	Solution A Concentrations (mg/L)	Solution B Concentrations (mg/L)
Al	20.0	20.0
Ca	60.0	60.0
Fe	50.0	50.0
Mg	20.0	20.0
Na	50.0	50.0
P	20.0	20.0
K	20.0	20.0
S	20.0	20.0
C	40.0	40.0
Cl	424	424
Mo	0.05	0.05
Ti	0.40	0.40
As	0.0	0.025
Cd	0.0	0.025
Cr	0.0	0.050
Co	0.0	0.050
Cu	0.0	0.050
Mn	0.0	0.050
Ni	0.0	0.050
Se	0.0	0.025
Ag	0.0	0.0125
V	0.0	0.050
Zn	0.0	0.025

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NOTE: The concentration of interfering elements in the ICSA and ICSAB solutions are spiked at levels 5 times lower than recommended in Table 1 of Method 6020A. Running the full strength solutions as described in 6020A introduces too much material approximately 0.35 % dissolved solids into the ICP-MS system when trying to conduct low level analysis. Since the ICP-MS instrumentation is able to handle a maximum of 0.2% solids, the 6020A ICSA solution is higher in interfering components than any sample that would run through the instrument. However, the ICS solutions will be analyzed at levels that will provide approximately 0.1% dissolved solids.

12.8 Internal standards are used to correct for physical interferences. Masses used as internal standards include; ^{71}Ga, ^{115}In, ^{6}Li, ^{175}Lu, ^{103}Rh ^{45}Sc, and ^{89}Y. These internal standards are used in combination to cover the appropriate mass ranges. Internal standard correction is applied to the analytical isotopes via interpolation of the responses form nearest internal standard isotopes. This function is performed in real-time by the instruments operating system. Internal standards must be run within 50 AMU of the masses that are analyzed. When the intensity of an internal standard is less than 30 % or greater than 120% of the intensity measured in the original calibration blank, the sample must be reanalyzed after a fivefold or greater dilution has been performed.

12.9 A method blank is digested and analyzed with every batch of 20 (or fewer) samples to demonstrate that there are no method interferences. If the method blank shows any hits above the MRL for standard applications, or >½ the MRL for DoD projects or > 1/10 the sample result, corrective action must be taken. The MB can only be rerun once. Corrective action includes recalculation, reanalysis, system cleaning, or re-extraction and reanalysis.

12.10 Laboratory Control Samples are analyzed at a frequency of 5% or one per batch, whichever is greater. See the Attachments for a listing of control limits. For method 6020A, the LCS recovery limits are 80-120%. If statistical in-house limits are used, they must fall within the 80-120% range. Project, QAPP, or client-specific control limits may supersede the limits listed, but laboratory limits should be consistent with specified limits in order to establish that the specified limits can be achieved. If the control limits are exceeded, the associated batch of samples will be redigested and reanalyzed.

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12.11 A digested duplicate and matrix spike are analyzed at a frequency of 5% or one per batch, whichever is greater. The matrix spike recovery and relative percent difference will be calculated while analysis is in progress. See the Attachments for a listing of control limits. Project, QAPP, or client-specific control limits may supercede the limits listed. If the control limits are exceeded, the samples will be redigested and reanalyzed, unless matrix interference or sample non-homogeneity is established as cause. In these instances, the data and the report will be flagged accordingly.

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12.12 A Matrix Spike sample is digested one per batch, or per 20 samples (i.e. 5%). Default spike concentrations are listed in the sample digestion SOPs. Spike concentrations may be adjusted to meet project requirements. The matrix spike recovery will be calculated while the job is in progress. Where specified by project requirements, a matrix spike duplicate may be required. Matrix spike recovery criteria are derived from lab data and are listed in Table 2. For method 6020A, the recovery limits are 75-125%. If statistical in-house limits are used, they must fall within the 75-125% range. In some cases, project-specific QC limits may be required. Unless specified otherwise, for DoD QSM projects the project LCS criteria will be used for evaluation of matrix spikes. If an analyte recovery is outside acceptance limits proceed with the additional quality control tests described in sections 12.13 and 12.14. Based on results of these tests, the physical nature of the sample (e.g. homogeneity), and any specific project requirements, a determination can then be made as to appropriate corrective action (e.g. redigestion, reporting with a qualifier, alternative methodologies, etc.). If the analyte concentration is >4x the spike level the spike control limit is no longer applicable and no action is required. For specifics on the preparation and composition of matrix spike solutions refer to the appropriate digestion SOP.
Note: For DOD projects a MS/MSD is required with every extraction batch. The %RSD should be < 20%.

12.13 Post Digestion Spike Test: When analysis is conducted via 6020 a post digestion spike must be performed for each matrix and each batch of sample. The prepared sample or its dilution is spiked for each element of interest at a concentration sufficiently high to be observed. Typically 20 µL of 10,000 ppb intermediate stock is added to a 10 mL aliquot of sample. If analyte concentrations are elevated in the sample, spiking at a higher concentration may be required. The post spike should be recovered to within 75-125% of the known value or within the laboratory derived acceptance criteria. When analysis is conducted via 6020A the post digestion spike test is performed whenever matrix spike criteria are exceeded. An analyte spike is added to a portion of a prepared sample, or its dilution, and should be recovered to within 80% to 120% of the known value. If this spike fails, then the dilution test (Sec. 12.14) should be run on this sample. If both the matrix spike and the post digestion spike fail, then matrix effects are confirmed.

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12.14 Dilution Test: When analysis is conducted via 6020, a serial dilution test must be performed for each matrix and each batch of sample. For sample concentrations that are sufficiently high (minimally, a factor of greater than 100 times the MDL), the analysis of a fivefold (1+4) dilution must agree within ± 10% of the original determination. When analysis are conducted via 6020A the dilution test is performed whenever matrix spike and post digestion spike criteria are exceeded, when a new and unusual matrix is encountered, and with all Tier III projects.

12.15 Instrument blanks should be evaluated for potential carryover and rinse times need to bring the analyte signal to within the CCB criteria discussed above in section 12.4. Results from instrument blanks run after standards or control samples should be used to establish levels at which carryover in samples may occur. Samples exhibiting similar effects of carryover should be reanalyzed.

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12.16 Refer to the Quality Control section of EPA Methods 6020 and 6020A for additional information describing required QA/QC. Note that the nomenclature of certain QC samples in the method differs from that of the CLP SOW, but the function of those samples is equivalent in both cases.

13 DATA REDUCTION, REPORTING, AND REVIEW

13.1 Calculations

Calculate sample results using the data system printouts and digestion information. the digestion and dilution information is entered into the data system. The data system then uses the calculations below to generate a sample result.

Aqueous samples are reported in µg/L:

$$\mu g / L\ (Sample) = C^{*} \times Digestion\ Dilution\ Factor \times Post\ Digestion\ Dilution\ Factor$$

C*= Concentration of analyte as measured at the instrument in ug/L (in digestate).

Solid samples are reported in mg/Kg:

$$mg/Kg(Sample) = C^{*} \times PostDigestionDilutionFactor \times \frac{DigestionVol.(ml)}{Samplewt.(g)} \times \frac{1mg}{1000ug} \times \frac{1L}{1000ml} \times \frac{1000g}{1Kg}$$

C*= Concentration of analyte as measured at the instrument in ug/L (in digestate).

NOTE: If results are to be reported on a dry weight basis, determine the dry weight of a separate aliquot of the sample, using the SOP for Total Solids.

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13.2 Common isobaric interferences are corrected using equations equivalent to those listed in EPA Methods 6020, 6020A, and 200.8. Monitoring of multiple isotopes for a single element provides a mechanism for identifying isobaric interferences. Refer to the Interferences section of EPA methods for additional descriptions of possible interferences and the mechanisms required for adequately compensating for their effects.

13.3 Data Review and Reporting

13.3.1 The ICP-MS operator reviews the MS data and signs and dates the Data Review Form. A qualified senior staff spectroscopist performs a secondary review of the data and the Data Review Form is signed and dated. The data is then delivered to the report generation area where it is filed in the service request file. Once all of the data for the service request is complete, a CAR is generated.

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13.3.2 The data is saved on the local hard drive and is also copied to the appropriate directory on the network. The data directories are located at r:\icp\wip\data. The data is kept on the local directory for 1 month. The network files are periodically backed up on disc or network tape.

13.3.3 For "non-production" work (such as method development or research/development studies) the analyses are performed under the direction of a senior spectroscopist. All associated data is scrutinized by the senior spectroscopist. Original raw data and associated records are archived in the analytical project file.

13.3.4 The final review and approval of all data is performed by qualified spectroscopists.

14 CONTENGENCIES FOR HANDLING OUT-OF-CONTROL OR UNACCEPTABLE DATA

Corrective action measures applicable to specific analysis steps are discussed in the applicable section of this (and other applicable) SOP(s). Also, refer to the SOP for *Nonconformity and Corrective Action* for correct procedures for identifying and documenting such data. Procedures for applying data qualifiers are described in the SOP for *Report Generation* or in project-specific requirements.

15 METHOD PERFORMANCE

This method was validated through single laboratory studies of accuracy and precision. Refer to the reference method for additional available method performance data.

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The method detection limit (MDL), limit of detection (LOD) and limit of quantitation (LOQ) are established using procedures described in the SOP for *The Determination of Method Detection Limits and Limits of Detection* (ADM-MDL). Method Reporting Limits are established for this method based on MDL studies and as specified in the CAS Quality Assurance Manual.

16 TRAINING

16.1 A minimum of two senior level spectroscopists are to be maintained on staff at all times. Senior spectroscopists are defined as individuals with a minimum of ten years combined education and experience in, or related to atomic spectroscopy. Of those ten years, a minimum of two years of ICP-MS experience is required.

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16.2 All technical staff is encouraged to attend one technical seminar per year. In addition to the technical seminars, senior spectroscopists are required to complete a one week training session offered by the instrument manufacturer.

16.3 Training outline

16.3.1 Review literature (see references section). Read and understand the SOP. Also review the applicable MSDS for all reagents and standards used. Following these reviews, observe the procedure as performed by an experienced analyst at least three times.

16.3.2 The next training step is to assist in the procedure under the guidance of an experienced analyst. During this period, the analyst is expected to transition from a role of assisting, to performing the procedure with minimal oversight from an experienced analyst.

16.3.3 Perform initial precision and recovery (IPR) study as described above for water samples. Summaries of the IPR are reviewed and signed by the supervisor. Copies

may be forwarded to the employee's training file. For applicable tests, IPR studies should be performed in order to be equivalent to NELAC's Initial Demonstration of Capability.

16.4 Training and proficiency is documented in accordance with the SOP ADM-TRANDOC.

17 POLLUTION PREVENTION

It is the laboratory's practice to minimize the amount of solvents and reagents used to perform this method wherever technically sound, feasibly possible and within method requirements. Standards are prepared in volumes consistent with the laboratory use in order to minimize the volume of expired standards to be disposed of. The threat to the environment from solvents and/or reagents used in this method may be minimized when recycled or disposed of properly.

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18 WASTE MANAGEMENT

The laboratory will comply with all Federal, State and local regulations governing waste management, particularly the hazardous waste identification rules and disposal restrictions as specified in the laboratory Safety Manual, Sections 6 and 7.

19 CHANGES SINCE THE LAST REVISION

19.1 Sec 1.1 Added clarification
19.2 Sec 7 Removed obsolete instruments
19.3 Sec 12.12 Added guidance for evaluating MS recoveries and MS/MSD DOD requirements.
19.4 Sec 12.13 Added post digestion spike requirements.
19.5 Sec 12.14 Added dilution test requirements.
19.6 Sec 12.4 Added DOD grey box 33 requirements.
19.7 Sec 15 Added reference to MDL SOP.

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20 REFERENCES

20.1 USEPA, Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition, Update III Method 6020, Revision 0, September 1994.

20.2 USEPA, Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition, Update IV, Method 6020A, Revision 1, February 2007.

20.3 Method 200.8 - Determination of Trace Elements in Waters and Wastes By Inductively Coupled Plasma-Mass Spectrometry, USEPA-EMSL, Revision 5.4, 1994.

20.4 VG and Thermo Elemental Instrument Manuals

TABLE 1

Method Reporting Limits and Method Detection Limits – Water Matrix

	Water (ug/L)			**Water (ug/L)**			**Seawater (ug/L)**		
	CLP Digestion			3020 Digestion			Reductive Precipitation		
Analyte	MRL (DoD)	**MRL**	**MDL**	MRL (DoD)	**MRL**	**MDL**	MRL (DoD)	**MRL**	**MDL**
Aluminum	2	**2**	**0.3**	2.4	**2**	**0.8**	-	-	-
Antimony	0.09	**0.05**	**0.03**	0.09	**0.05**	**0.03**	-	-	-
Arsenic	0.5	**0.5**	**0.08**	0.5	**0.5**	**0.07**	0.5	**0.5**	**0.02**
Barium	0.06	**0.05**	**0.02**	0.12	**0.05**	**0.04**			
Beryllium	0.02	**0.02**	**0.008**	0.02	**0.02**	**0.006**	0.02	**0.02**	**0.0007**
Bismuth	0.1	**0.1**	**0.02**	-	-	-	-	-	-
Boron	0.9	**0.5**	**0.3**	-	-	-	-	-	-
Cadmium	0.02	**0.02**	**0.008**	0.06	**0.02**	**0.02**	0.02	**0.02**	**0.006**
Chromium	0.2	**0.2**	**0.07**	0.2	**0.2**	**0.05**	0.2	**0.2**	**0.03**
Cobalt	0.02	**0.02**	**0.005**	0.02	**0.02**	**0.005**	0.02	**0.02**	**0.001**
Copper	0.1	**0.1**	**0.02**	0.21	**0.1**	**0.07**	0.1	**0.1**	**0.03**
Lead	0.03	**0.02**	**0.009**	0.06	**0.05**	**0.02**	0.02	**0.02**	**0.003**
Manganese	0.06	**0.05**	**0.02**	0.05	**0.05**	**0.01**	-	-	-
Molybdenum	0.09	**0.05**	**0.03**	0.09	**0.05**	**0.03**	-	-	-
Nickel	0.2	**0.2**	**0.07**	0.2	**0.2**	**0.05**	0.2	**0.2**	**0.03**
Selenium	1.2	**1**	**0.4**	1	**1**	**0.2**	-	-	-
Silver	0.03	**0.02**	**0.009**	0.03	**0.02**	**0.009**	0.02	**0.02**	**0.004**
Thallium	0.02	**0.02**	**0.003**	0.02	**0.02**	**0.004**	0.02	**0.02**	**0.0009**
Tin	0.1	**0.1**	**0.04**	-	-	-	-	-	-
Uranium	0.02	**0.02**	**0.005**	0.02	**0.02**	**0.004**	-	-	-
Vanadium	0.2	**0.2**	**0.08**	0.2	**0.2**	**0.05**	-	-	-
Zinc	0.5	**0.5**	**0.1**	0.6	**0.5**	**0.2**	0.5	**0.5**	**0.04**

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TABLE 1 (continued)
Method Reporting Limits and Method Detection Limits – Solid Matrix

	Soil/Sediment (mg/kg)			Tissue (mg/kg, dry basis)		
	3050 Digestion			PSEP		
Analyte	MRL (DoD)	**MRL**	**MDL**	MRL (DoD)	**MRL**	**MDL**
Aluminum	2	**2**	**0.5**	2	**2**	**0.4**
Antimony	0.09	**0.05**	**0.03**	0.06	**0.05**	**0.02**
Arsenic	0.5	**0.5**	**0.1**	0.5	**0.5**	**0.05**
Barium	0.09	**0.05**	**0.03**	0.15	**0.05**	**0.05**
Beryllium	0.06	**0.02**	**0.02**	0.02	**0.02**	**0.005**
Bismuth	0.1	**0.1**	**0.02**	-	-	-
Cadmium	0.02	**0.02**	**0.008**	0.03	**0.02**	**0.01**
Chromium	0.2	**0.2**	**0.04**	-	-	-
Cobalt	0.02	**0.02**	**0.003**	0.02	**0.02**	**0.006**
Copper	0.3	**0.1**	**0.1**	0.1	**0.1**	**0.03**
Lead	0.06	**0.05**	**0.02**	0.02	**0.02**	**0.006**
Manganese	0.12	**0.05**	**0.04**	0.06	**0.05**	**0.02**
Molybdenum	0.15	**0.05**	**0.05**	0.06	**0.05**	**0.02**
Nickel	0.2	**0.2**	**0.05**	0.2	**0.2**	**0.03**
Selenium	2	**1**	**0.4**	-	-	-
Silver	0.06	**0.02**	**0.02**	0.02	**0.02**	**0.006**
Thallium	0.02	**0.02**	**0.003**	0.02	**0.02**	**0.005**
Tin	0.2	**0.1**	**0.06**	-	-	-
Uranium	0.02	**0.02**	**0.004**	0.02	**0.02**	**0.007**
Vanadium	0.2	**0.2**	**0.04**	0.2	**0.2**	**0.04**
Zinc	0.6	**0.5**	**0.2**	1.2	**0.5**	**0.4**

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ATTACHMENTS

List of Target Element Masses
Example Standard Sheet
Instrument Logs
QC Acceptance Criteria

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Analyte	ISOTOPES ANALYZED	ISOTOPE REPORTED
Aluminum	27	27
Antimony	121,123	123
Arsenic	75	75
Barium	135,137,138	137
Beryllium	9	9
Cadmium	111,112,114	111
Chromium	52,53	52
Cobalt	59	59
Copper	63,65	65
Lead	206,207,208	208
Manganese	55	55
Molybdenum	95,97,98	98
Nickel	60,61,62	60
Selenium	77,78,82	82
Silver	107,109	107
Thallium	203,205	205
Uranium	238	238
Vanadium	51	51
Zinc	66,67,68	66

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METALS SPIKE FORM

Service Request #_____
Q.C. Sample #_____

Circle type of digest: GFAA ICP FAA ICP-MS Other:_____ Initials / Date:_____/_____
Circle type of sample: Soil Water Misc. Sludge Oil Other:_____

Solution Name	Element	mls of 1000ppm Solution	Final Volume	Source	Lot#	Exp. Date	Solution Conc. mg/L	Enter mls Added	
SS1-MET1-55-H	HNO3	50.0	1000ml	JT Baker	C47031	-	-		Expires:7/1/07
	Al	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	200		
	Ag	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	5		
	Ba	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	200		
	Be	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	5		
	Cd	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	5		
	Co	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	50		
	Cr	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	20		
	Cu	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	25		
	Fe	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	100		
	Pb	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	50		
	Mn	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	50		
	Ni	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	50		
	Sb	50*	1000ml	MET1-50-J	Z-SB02097	7/1/2007	50		
	V	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	50		
	Zn	100	1000ml	MET1-54-D	Z-MEB226030	1/1/2008	50		
SS4-MET1-52-T	HNO3	25.0	500ml	JT BAKER	A48046	-	-		Expires:7/11/07
	As	2.0	500ml	MET1-47-I	529701	7/11/2007	4		
	Cd	2.0	500ml	MET1-49-L	605906	12/15/2007	4		
	Pb	2.0	500ml	MET1-50-C	611804	12/15/2007	4		
	Se	2.0	500ml	MET1-49-M	616579	12/15/2007	4		
	Tl	2.0	500ml	MET1-49-O	616317	12/15/2007	4		
	Cu	2.0	500ml	MET1-50-E	611815	12/15/2007	4		
SS5-MET1-54-G	HNO3	25.0	500ml	JT BAKER	B41068	-	-		Expires:7/1107
	As	50.0	500ml	MET1-47-I	529701	7/11/2007	100		
	Se	50.0	500ml	MET1-49-M	616519	12/15/2007	100		
	Tl	50.0	500ml	MET1-49-O	616317	12/15/2007	100		
SS6-MET1-54-E	HNO3	25	500ml	JT BAKER	C28025	-	-		Expires: 7/01/07
	B	50	500ml	MET1-51-C	Z-QB02041	7/1/2007	100		
	Mo	50	500ml	MET1-54-K	Z-MO02012	2/1/2008	100		
GFLCSW (MET1-52-W)	HNO3	10.0	1000ml	JT BAKER	C28025	-	-		Expires: 8/1/07
	As, Pb, Se, Tl	5.0	1000ml	QCP-CICV-3	Y-MEB194030	8/1/2007	2.5		
	Cd	-	-	QCP-CICV-3	Y-MEB194030	8/1/2007	1.25		
	Cu	2.5	1000ml	MET1-50-E	611815	12/15/2007	2.5		
QCP-CICV-1 (MET1-52-I)	Ca, Mg, Na, K	no dilution	-	IV	Z-MEB194088	9/1/2007	2500		Expires:9/1/07
	Al, Ba	no dilution	-	IV	Z-MEB194088	9/1/2007	1000		
	Fe	no dilution	-	IV	Z-MEB194088	9/1/2007	500		
	Co, Mn, Ni, V, Zn	no dilution	-	IV	Z-MEB194088	9/1/2007	250		
	Cu, Ag	no dilution	-	IV	Z-MEB194088	9/1/2007	125		
	Cr	no dilution	-	IV	Z-MEB194088	9/1/2007	100		
	Be	no dilution	-	IV	Z-MEB194088	9/1/2007	25		
QCP-CICV-2 (MET1-54-Q)	Sb	no dilution	-	IV	Z-CICP19033	3/1/2008	500		Expires: 3/1/08
QCP-CICV-3 (MET1-51-U)	As, Pb, Se, Tl	no dilution	-	IV	Y- MEB194030	8/1/2007	500		Expires: 08/01/07
	Cd	no dilution	-	IV	Y- MEB194030	8/1/2007	250		

* Denotes volume of 1000 ppm stock standard.

Element	mls of	ppm	Source	Lot# / Lab Code	Exp. Date

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Columbia Analytical Services, Inc.
PQ ExCell ICP-MS Service Request Run Log

Date of Analysis	ICP-MS Method	Experiment Name	Service Request #	Sample #'s	Calibration Data w/Sr #	Analyst	Comments

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METALS ANALYSES						
Method	Prep Method	Matrix	Analyte	LCS Accuracy (% Rec.)	Matrix Spike (% Rec.)	Precision (RPD)
6020	3050B	Soil/Sed.	Aluminum	Ref.	75-125	20
6020	3050B	Soil/Sed.	Antimony	35-158	10-107	20
6020	3050B	Soil/Sed.	Arsenic	74-126	56-136	20
6020	3050B	Soil/Sed.	Barium	78-147	55-176	20
6020	3050B	Soil/Sed.	Beryllium	78-147	66-134	20
6020	3050B	Soil/Sed.	Boron	Ref.	75-125	20
6020	3050B	Soil/Sed.	Cadmium	77-133	68-136	20
6020	3050B	Soil/Sed.	Chromium	71-137	33-180	20
6020	3050B	Soil/Sed.	Cobalt	91-132	78-120	20
6020	3050B	Soil/Sed.	Copper	69-144	28-174	20
6020	3050B	Soil/Sed.	Lead	75-138	31-178	20
6020	3050B	Soil/Sed.	Manganese	Ref.	75-125	20
6020	3050B	Soil/Sed.	Molybdenum	73-142	53-143	20
6020	3050B	Soil/Sed.	Nickel	78-140	62-134	20
6020	3050B	Soil/Sed.	Selenium	80-140	66-122	20
6020	3050B	Soil/Sed.	Silver	78-128	61-133	20
6020	3050B	Soil/Sed.	Thallium	75-123	74-130	20
6020	3050B	Soil/Sed.	Uranium	Ref.	75-125	20
6020	3050B	Soil/Sed.	Vanadium	74-143	60-155	20
6020	3050B	Soil/Sed.	Zinc	78-140	33-161	20
6020	CLP/3020A	Water	Aluminum	81-122	61-140	20
6020	CLP/3020A	Water	Antimony	90-111	59-135	20
6020	CLP/3020A	Water	Arsenic	88-112	74-126	20
6020	CLP/3020A	Water	Barium	92-110	84-120	20
6020	CLP/3020A	Water	Beryllium	79-124	66-128	20
6020	CLP/3020A	Water	Cadmium	90-111	84-113	20
6020	CLP/3020A	Water	Chromium	86-115	68-126	20
6020	CLP/3020A	Water	Cobalt	84-117	82-117	20
6020	CLP/3020A	Water	Copper	87-114	63-126	20
6020	CLP/3020A	Water	Lead	89-112	71-119	20
6020	CLP/3020A	Water	Manganese	84-120	69-134	20
6020	CLP/3020A	Water	Molybdenum	74-126	57-145	20
6020	CLP/3020A	Water	Nickel	87-114	74-119	20
6020	CLP/3020A	Water	Selenium	85-116	63-132	20
6020	CLP/3020A	Water	Silver	86-111	57-130	20
6020	CLP/3020A	Water	Thallium	87-114	68-125	20
6020	CLP/3020A	Water	Vanadium	83-116	76-124	20
6020	CLP/3020A	Water	Zinc	83-121	62-126	20

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STANDARD OPERATING PROCEDURE

TRACE METALS IN WATER BY PRE-CONCENTRATION USING REDUCTIVE PRECIPITATION FOLLOWED BY ICP-MS ANALYSIS

SOP No.: MET-RPMS

Revision: 5

February 14, 2008

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Approved by: _____ Supervisor — 2/15/08 Date

_____ QA Manager — 2-15-08 Date

_____ Laboratory Manager — 2/15/08 Date

COLUMBIA ANALYTICAL SERVICES, INC.
1317 South 13th Avenue
Kelso, Washington 98626

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Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date: _____

TRACE METALS IN WATER BY PRE-CONCENTRATION USING REDUCTIVE PRECIPITATION FOLLOWED BY ICP-MS ANALYSIS

1. SCOPE AND APPLICATION

1.1. This method is applicable to the analysis of aqueous samples, including seawater for ultra trace level metallic constituents. The method provides a means of separating metal analyte(s) from complex sample matrices such as seawater, pore water, and certain surface and ground waters prior to instrumental analysis. The method allows for the simultaneous analysis of beryllium, chromium, cobalt, nickel, copper, zinc, arsenic, silver, cadmium, tin, antimony, mercury, thallium, and lead.

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1.2. The Method Reporting Limits (MRLs) will vary depending on the quality of reagents and the care taken to avoid contamination during the reductive precipitation procedure. The MRLs listed in Table 1 represent estimated limits.

2. SUMMARY OF METHOD

This aqueous sample is treated with iron and palladium carriers, pH adjusted, and then subjected to reducing conditions using sodium tetrahydridoborate. The resulting precipitate consists of metals reduced to the elemental state, as well as metals precipitated as the boride. The precipitate is isolated using filtration or centrifugation techniques, then redissolved in concentrated acids. The resulting solution represents a 5-10 fold concentration of the trace metal constituents. The solution is analyzed by ICP-MS, using EPA Method 200.8 with the appropriate modifications to accommodate the 0.024 N HCl in the digestate. Also, in order to improve matrix spike recoveries for Nickel, which can be problematic in some saline matrices, isotope dilution is utilized. 61Ni is added as a surrogate prior to the reducing step, and then used in the quantification of 60Ni in the final digestate.

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3. DEFINITIONS

3.1. **Analysis Sequence** - Samples are analyzed in a set referred to as an analysis sequence. The sequence begins with instrument calibration followed by sample digestates interspersed with calibration standards.

3.2. **Independent Calibration Verification (ICV)** - ICV solutions are made from a stock solution which is different from the stock used to prepare calibration standards and is used to verify the validity of the standardization.

3.3. **Matrix Spike** (MS) - In the MS analysis, predetermined quantities of standard solutions of certain analytes are added to a sample matrix prior to sample digestion and analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for each of the analytes detected.

3.4. **Matrix Spike Duplicate** (MSD) - In the matrix spike duplicate analysis, predetermined quantities of standard solutions of certain analytes are added to a sample matrix prior to sample digestion and analysis. The purpose of the matrix spike duplicate is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for each of the analytes detected. The relative percent difference between the matrix spikes is calculated and used to assess analytical precision.

3.5. **Duplicate Sample** (DUP) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess precision.

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3.6. **Method Blank** - The method blank is an artificial sample designed to monitor introduction of artifacts into the process. The method blank is carried through the entire analytical procedure.

3.7. **Continuing Calibration Verification Standard (CCV)** - A standard analyzed at specified intervals and used to verify the ongoing validity of the instrument calibration.

3.8. **Instrument Blank (CCB)** - The instrument blank (also called continuing calibration blank) is a volume of blank reagent of composition identical to the digestates. The purpose of the CCB is to determine the levels of contamination associated with the instrumental analysis.

4. INTERFERENCES

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4.1. Common interferences are documented in the CAS SOPs for Methods 200.8 and 6020.

4.2. Calibration blanks and standards are matrix matched to the samples with 0.048 N HCl, 0.4 N HNO_3, and 20 mg/L each of iron and palladium carrier.

4.3. Interferences correction equations:

$^{77}Se = I82 \times 0.8484$

$^{40}Ar^{37}C1 = I77 - {}^{77}Se$

$^{40}Ar^{35}C1 = {}^{40}Ar^{37}C1 \times 3.0650$

$^{75}As = I75 - {}^{40}Ar^{35}C1$

$^{114}Cd = I114 - 0.0268 \times I118 - 1.6285 \times I108$

$^{208}Pb = I208 + I207 + I206$

4.4. The $C1^-$ on Cr has to be corrected via matrix matching. Detection limits will suffer accordingly.

4.5. Some Mg carries over to the final solution. Manual corrections must be performed for $^{24}Mg^{35}C1^+$ interference on ^{59}Co.

5. SAFETY

5.1. All appropriate safety precautions for handling solvents, reagents and samples must be taken when performing this procedure. This includes the use of personnel protective equipment, such as, safety glasses, lab coat and the correct gloves.

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5.2. Chemicals, reagents and standards must be handled as described in the CAS safety policies, approved methods and in MSDSs where available. Refer to the CAS Environmental, Health and Safety Manual and the appropriate MSDS prior to beginning this method.

5.3. Hydrochloric and/or Nitric Acid are used in this method. These acids are extremely corrosive and care must be taken while handling them. A face shield should be used while pouring acids. And safety glasses should be worn while working with the solutions. Lab coat and gloves should always be worn while working with these solutions.

5.4. High Voltage - The RF generator supplies up to 2000 watts to maintain an ICP. The power is transferred through the load coil located in the torch box. Contact with the load coil while generator is in operation will likely result in death. When performing maintenance on the RF generator, appropriate grounding of all HV capacitors must be performed as per manufacturer.

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5.5. UV Light - The plasma is an intense source of UV emission, and must not be viewed with the naked eye. Protective lenses are in place on the instrument. Glasses with special protective lenses are available when direct viewing of the plasma is necessary.

6. SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

Aqueous samples are collected in plastic bottles and preserved with nitric acid (pH < 2). Samples are stored at 4 ± 2°C. The holding time is six months from sample collection.

7. APPARATUS & EQUIPMENT

7.1. See CAS SOP for *Determination of Metals andTrace Elements by Inductively Coupled - Mass Spectrometry – Method 200.8* (MET-ICPMS) for ICP-MS requirements.

7.2. Polysulfone 25-mm filter holder with maximum reservoir size.

7.3. 0.2 µm membrane filter (25 mm). Use Gelman Supor-200 filters or equivalent.

7.4. 0.45 µm acid resistant membrane filters (25mm). Use Gelman FP-Vericel or equivalent.

7.5. 1000 or 500mL Teflon Bottles.

7.6. 1000 mL Polycarbonate bottles.

7.7. Centrifuge capable of spinning 1000 mL bottles at 3000 rpm.

7.8. 50mL centrifuge tubes.

7.9. Stir plate.

7.10. pH meter.

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8. STANDARDS, REAGENTS, & CONSUMABLE MATERIALS

8.1. See SOP for *Determination of Metals and Trace Elements by Inductively Coupled - Mass Spectrometry – Method 200.8* (MET-ICPMS) for standards and reagents for ICP-MS.

8.2. Concentrated nitric acid (Seastar or equivalent).

8.3. Concentrated hydrochloric acid (Seastar or equivalent).

8.4. Concentrated ammonium hydroxide (Seastar or equivalent).

8.5. Sodium tetrahydridoborate (Alpha Inorganics).

8.6. Ultrapure iron oxide; Fe_2O_3 (Spex or equivalent).

8.7. Ultrapure palladium metal (Spex or equivalent).

8.8. Six percent (6%) sodium tetrahydridoborate, $NaBH_4$.

8.8.1. Dissolve 6 g of $NaBH_4$ in ~75 mL of DI water and dilute to 100 mL. (Prepare less for fewer than 20 samples.)

8.8.2. Filter through 0.2 µm membrane filter.

8.9. Ten percent (10%) ammonium hydroxide: Dilute 10 mL concentrated ammonium hydroxide to 100 mL with DI water.

8.10. Fe and Pd solution (1,000 ppm).

8.10.1. Weigh 1.436 g Fe_2O_3 into a Teflon pressure vessel.

8.10.2. Add 4 mL concentrated HCI and 4 mL concentrated HNO_3, seal, and place in a 105°C oven for 24-48 hours.

8.10.3. Weigh 1.000 g Pd into a Teflon pressure vessel.

8.10.4. Add 4 mL concentrated HCI and 4 mL concentrated HNO_3, seal, and place in a 105°C oven for 24-48 hours.

8.10.5. Remove the pressure vessels from the oven cool, and inspect to assure all solids are dissolved.

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8.10.6. Quantitatively combine the contents of each Teflon pressure vessel in a 1000 mL Teflon bottle and dilute to 1000 mL with DI water.

8.11. 50 mg/L enriched ^{61}Ni stock standard. (^{61}Ni metal available from Cambridge Isotope Laboratories)

8.12. 1 mg/L enriched ^{61}Ni working standard.

9. PREVENTIVE MAINTENANCE

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9.1. All maintenance is documented in the instrument logbook. CAS/Kelso maintains a service contract with the instrument manufacturer that allows for an unlimited number of service calls and full reimbursement of all parts and labor.

9.2. Most routine maintenance and troubleshooting is performed by CAS staff. Preventive maintenance activities listed below should be performed when needed as determined by instrument performance (i.e. stability, sensitivity, etc.) or by visual inspection. Other maintenance or repairs may, or may not require factory service, depending on the nature of the task.

- cone removal and cleaning
- removal and cleaning of ICP glassware and fittings
- checking and cleaning RF contact strips
- checking air filters and cleaning if necessary
- checking the oil mist filters and cleaning if necessary
- checking the rotary pump oil and adding or changing if necessary
- removal and cleaning of extraction lens
- removal and cleaning of ion lens stack
- replace the electron multiplier as necessary

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. It is also the responsibility of the analyst to read and understand the appropriate method. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. This demonstration is in accordance with the training program of the laboratory. Final review and sign-off of the data is performed by the department supervisor/manager or designee.

10.2. It is the responsibility of the department supervisor/manager to document analyst training. Documenting method proficiency, as described in the applicable EPA method, is also the responsibility of the department supervisor/manager.

11. PROCEDURE

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11.1. All laboratory equipment (i.e., glassware, filtration apparatus, etc.), which comes in contact with the sample or digestate during the analysis must be thoroughly pre-cleaned with 25% HCl and rinsed with DI water.

11.2. All sample preparation steps that expose the sample to the atmosphere must be performed in a Class 100 laminar flow hood. All other operations are performed in the clean room (Class 1000 or better).

11.3. Place a 1000 mL aliquot of sample in a Teflon reaction vessel if the precipitate separation is to be done by filtration, or alternately in a polycarbonate reaction vessel if the precipitate separation is to be done by centrifugation. Add 2.0 mL of the Pd/Fe carrier solution. A sample size less than 1000mL may be used if insufficient sample volume has been provided.

Note: 2.0 mL = 2 mg Pd + 2 mg Fe

11.4. Prepare the Method Blank, LCS, Duplicates and Matrix Spikes for at least 5% of the samples. Use a volume of DI water for the Method Blank and LCS that is equivalent to the final volume of the sample being digested. The LCS and Matrix Spike are spiked with 2.0 mL each of the 200.8 and Silver Standard Solutions. Finally, to all field and QC samples add 0.08 mL of 50 mg/L 61Ni stock solution when Nickel is a target analyte.

11.5. Adjust the sample pH to 8.5 ± 0.2 with concentrated and 10%$NH_4$0H.

11.6. Add 5 mL of 6% $NaBH_4$ for volumes of 500–1000 mL and swirl to mix. Use 2.5 mL for 500 mL or less of sample.

Note: Prepare $NaBH_4$ just prior to use.

11.7. Allow the reaction vessels to stand with caps loosely in place for at least 15 hours.

11.8. Precipitate Separation

11.8.1. Filtration Method

11.8.1.1. Clean 0.45 µm acid resistant filters ("Vericel") by adding them to aqua regia (4:1 HCl:HNO3) for 20 minutes. Rinse the filters with DI water. Rinse twice by drawing DI water through the filters with vacuum. Do not let the filters dry out once they are treated with aqua regia and rinsed with water.

11.8.1.2. Filter the sample through the precleaned Vericel filter.

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11.8.1.3. Carefully transfer the filter back to the original reaction vessel.

11.8.2. Centrifugation Method

11.8.2.1. Group according to weight and fill an empty bottle to correspond with any odd samples in order to insure the centrifuge is balanced.

11.8.2.2. Centrifuge the polycarbonate reaction vessels for 30 minutes at 3000 rpm

11.8.2.3. Remove immediately from centrifuge, being sure not to disturb the precipitate. Note: It is important that the remaining separation steps are performed very soon after removing the samples from the centrifuge

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11.8.2.4. Carefully transport the reaction vessels to the clean room

11.8.2.5. Remove the supernate by careful decanting or aspiration. Note: Some samples yield a very light precipitate that cannot easily be separated from the supernate. In these cases the separation will have to be done by filtration.

11.9. Add 2.5 mL concentrated HNO_3 and 0.4 mL concentrated HCl to the reaction flask. Cap and seal tight.

11.10. Swirl and warm under hot tap water to dissolve the material on the filter and any solids absorbed to the walls of the container.

11.11. Add approximately 25 mL of DI water to the flask and shake. Transfer the solution to a 50mL centrifuge tube. Dilute to 50mL. Pour the solution into the reaction flask.

11.12. Fill the centrifuge tube with 50mL of DI water. Add this to the reaction flask (total volume = 100mL). Cap and shake to mix the contents. Add 50mL to the centrifuge tube.

11.13. Add the appropriate internal standard.

11.14. Analyze by ICP-MS (CAS SOP MET-ICPMS) using the following analytical masses:

^{9}Be	^{75}As	^{200}Hg
^{52}Cr	^{82}Se	^{205}Tl
^{59}Co	^{109}Ag	^{208}Pb
^{60}Ni	^{111}Cd	^{45}Sc – Internal Std.
^{65}Cu	^{120}Sn	^{115}In – Internal Std.
^{66}Zn	^{133}Sb	^{175}Lu – Internal Std.

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12. QA/QC REQUIREMENTS

12.1. Analyze a method blank, LCS, Duplicate, and Matrix Spike at a frequency of 5%, or one per sample batch, whichever is greater.

12.2. The control limits listed in the CAS MET-ICPMS SOP are used. Client specific QC recoveries may supersede the limits listed. If the control limits are exceeded, the samples will be redigested and reanalyzed, unless matrix interference or non-homogeneity can be established as the cause. In these instances, the data and report will be noted accordingly.

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12.3. A Continuing Calibration Verification (CCV) and Continuing Calibration Blank (CCB) are analyzed after every 10 samples. The control limits as listed in EPA Method 200.8 are used. If the control limits are exceeded, the instrument will be recalibrated and the previous 10 samples reanalyzed.

12.4. The baseline or slope can be corrected provided the previous and following CCV and CCB are within acceptable limits. If CCV or CCB are not within acceptable limits, the analysis is terminated, the problem found, and the instrument is then restandardized.

12.5. Instrument Detection Limits (IDLs), Method Detection Limits (MDLs), and linear ranges are performed periodically as per Method 200.8. These will be calculated and made available to the ICP-MS operator.

12.6. Common isobaric interferences are corrected using equations equivalent to those listed in EPA Method 200.8. Monitoring of multiple isotopes for a single element provides a mechanism for identifying isobaric interferences. The scope of this document does not allow for an in-depth discussion/training course pertaining to the interpretation of ICP-MS spectra. The final review and approval of all data is performed by qualified spectroscopists. Refer to the Interferences section of EPA Method 200.8 for additional descriptions of possible interferences and the mechanisms required for adequately compensating for their effects.

12.7. When analyzing for Nickel add ^{61}Ni to the calibration blank and standard at a level of 40 ug/L.

13. DATA REDUCTION, REPORTING, AND REVIEW

13.1. Calculations

Calculate sample results for each analyte using the data system printouts and digestion information. The digestion and dilution information is entered into the data system. The data system then uses the calculation below to generate a sample result. Aqueous samples are reported in µg/L.

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$$\mu g/L\ (Sample) = C_d \times Digestion\ DF \times Post\ Digestion\ Dilution\ Factor$$

where: C_d = Concentration measured at the instrument in mg/L (in digestate).
DF = Dilution factor

13.2. Common isobaric interferences are corrected using equations equivalent to those listed in EPA Method 200.8. Monitoring of multiple isotopes for a single element provides a mechanism for identifying isobaric interferences. Refer to the Interferences section of EPA Method 200.8 for additional descriptions of possible interferences and the mechanisms required for adequately compensating for their effects.

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13.3. Data Review and Reporting

13.3.1. Production

Data is reviewed by the ICP-MS operator and a report is generated. A senior spectroscopist performs a final review of the data and associated report. The data is then placed in the holding file until all analyses are complete. When the work order is complete, a final review is performed and the data is delivered to the project management department.

Tier III or higher type deliverables require a diskette of the ICP-MS data to be generated. The file is also stored on the hard drive of the ICP-MS until the data package has been generated.

13.3.2. Non-production

Method Development/Research and Development studies are performed under the direction of a senior spectroscopist. All associated data is scrutinized by the senior spectroscopist. Original raw data and associated records are archived in the analytical project file.

14. CONTENGENCIES FOR HANDLING OUT-OF-CONTROL OR UNACCEPTABLE DATA

Corrective action measures applicable to specific analysis steps are discussed in the applicable section of this (and other applicable) SOP(s). Also, refer to the SOP for *Nonconformity and Corrective Action* for correct procedures for identifying and documenting such data. Procedures for applying data qualifiers are described in the SOP for *Report Generation* or in project-specific requirements.

15. METHOD PERFORMANCE

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This method was validated through single laboratory studies of accuracy and precision. Refer to the reference method for additional available method performance data.

The method detection limit (MDL) is established using the procedure described in the SOP for *The Determination of Method Detection Limits and Limits of Detection* (ADM-MDL). Method Reporting Limits are established for this method based on MDL studies and as specified in the CAS Quality Assurance Manual.

16. POLLUTION PREVENTION

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It is the laboratory's practice to minimize the amount of solvents, acids and reagent used to perform this method wherever feasible. Standards are prepared in volumes consistent with methodology and only the amount needed for routine laboratory use is kept on site. The threat to the environment from solvent and reagents used in this method can be minimized when recycled or disposed of properly.

17. WASTE MANAGEMENT

17.1. The laboratory will comply with all Federal, State and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions as specified in the CAS EH&S Manual.

17.2. This method uses acid. Waste acid is hazardous to the sewer system and to the environment. All acid waste must be neutralized to a pH of 2.5-12 prior to disposal down the drain. The neutralization step is considered hazardous waste treatment and must be documented on the treatment by generator record. See the CAS EH&S Manual for details.

18. TRAINING

18.1. A minimum of two senior level spectroscopists are to be maintained on staff at all times. Senior spectroscopists are defined as individuals with a minimum of ten years combined

education and experience in, or related to atomic spectroscopy. Of those ten years, a minimum of two years of ICP-MS experience is required.

18.2. To maintain expertise in current technology, senior staff members are required to attend at least one technical seminar per year containing significant information relevant to ICP-MS. All technical staff are encouraged to attend one technical seminar per year.

18.3. In addition to the technical seminars, senior spectroscopists are required to complete a one week training session offered by the instrument manufacturer.

18.4. On-the-job-training occurs daily with the senior spectroscopists providing direction to new operators. The physical operation of the equipment is relatively simple. The data reduction and troubleshooting requires extensive experience that can only be gained by hands-on operation of the instrument and assisted evaluation of raw data.

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18.5. Training outline

18.5.1. Review literature (see references section). Read and understand the SOP. Also review the applicable MSDS for all reagents and standards used. Following these reviews, observe the procedure as performed by an experienced analyst at least three times.

18.5.2. The next training step is to assist in the procedure under the guidance of an experienced analyst. During this period, the analyst is expected to transition from a role of assisting, to performing the procedure with minimal oversight from an experienced analyst.

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18.5.3. Perform initial precision and recovery (IPR) study as described above for water samples. Summaries of the IPR are reviewed and signed by the supervisor. Copies may be forwarded to the employee's training file. For applicable tests, IPR studies should be performed in order to be equivalent to NELAC's Initial Demonstration of Capability.

18.6. Training is documented following the *SOP for Documentation of Training*.

NOTE: When the analyst training is documented by the supervisor on internal training documentation forms, the supervisor is acknowledging that the analyst has read and understands this SOP and that adequate training has been given to the analyst to competently perform the analysis independently.

19. REFERENCES

19.1. CAS SOP MET-ICPMS

19.2. Methods for Determination of Metals in Environmental Samples, USEPA Method 200.8, Revision 5.4, May 1994.

19.3. Determination of Trace Elements in Ambient Waters by On-Line Chelation Preconcentration and Inductively Coupled Plasma-Mass Spectrometry, USEPA Method 1640, January 1996.

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TABLE 1

ESTIMATED METHOD REPORTING LIMITS

Element	Estimated MRL (ppb)
Be	0.002
Cr	0.1
Co	0.003
Ni	0.05
Cu	0.04
Zn	0.3
As	0.1
Ag	0.005
Cd	0.009
Sn	0.01
Sb	0.009
Hg	0.009
Tl	0.009
Pb	0.02

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STANDARD OPERATING PROCEDURE

SAMPLE RECEIVING

SMO-GEN

Revision 25

April 9, 2009

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Approved By: _____ Supervisor — 4/13/09 Date

_____ QA Manager — 4/13/09 Date

_____ Laboratory Manager — 4/13/09 Date

COLUMBIA ANALYTICAL SERVICES, INC.
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Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date: _____

SAMPLE RECEIVING

1. PURPOSE

This procedure is used to facilitate the correct and expedient receipt, login, and storage of all samples received at CAS.

2. SCOPE AND APPLICATION

This procedure applies to all samples received at CAS. This procedure applies to all phases of sample handling once received, including checking and documentation of sample condition, documenting sample custody, sample login into the Laboratory Information Management System (LIMS), storage, shipping, and disposal

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3. RESPONSIBILITIES

3.1 It is the responsibility of all lab staff who handles samples to adhere to this procedure and to complete all documentation required. It is the responsibility of the department supervisor/manager to ensure that SMO staff is trained on this procedure and that training documentation is available. It is also the responsibility of the SMO supervisor to ensure that a secondary review of all sample login documentation is performed.

3.2 It is the responsibility of all CAS employees to ensure the confidentiality of client information. All information, such as customer name and project information, data, and reports is treated as confidential and is to be kept out of sight of other customers. No information may be given to third parties without the consent of the client.

4. DISCUSSION

4.1 The quality of analytical results is highly dependent upon the quality of the procedures used to collect and handle, and store samples. Therefore, sample management is a critical component of the laboratory operation. This procedure ensures that samples are properly received and logged into the Laboratory Information Management System (LIMS), and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received. Complete documentation of all sample storage is maintained in order to preserve the integrity of the samples and to establish a record of sample handling. All potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues.

4.2 During the log-in process, each sample is given a unique laboratory code and a service request form is generated. The service request contains client information, sample

descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information.

5. PROCEDURE

5.1 Sample receipt, unpacking, and inspection

5.1.1 Upon receipt, sample shipping containers are examined for presence and condition of custody seals, locks, shipping bills, etc. Before processing, all shipping containers (coolers) are initially opened in the hood. The cooler is quickly inspected for any existing hazards such as broken bottles and a thermometer is inserted. The CAS Cooler Receipt and Preservation Form (CRF – see Appendix) is used for the next steps. CAS follows EPA guidelines for preservation and holding time as outlined in the CAS *Quality Assurance Manual* Table 8-1.

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NOTE: If the cooler or any sample exhibits a strong odor, or there is any indication of highly contaminated samples, immediately transfer the cooler/samples to the hood if not already opened there. Ensure that appropriate protective equipment is being used (lab coat, gloves, eye protection, respirator if necessary, etc.). Continue to unpack the cooler. Leave the samples under the hood with the hood running. Notify the Project Chemist of the sample condition. For waste or product samples, store the samples in the hood in SMO. For other samples (water, soil/solid, etc) store the samples in the walk-in cooler(s). If any of the suspect or highly contaminated samples are designated for VOA analysis, DO NOT store with the other VOA samples in the VOA sample refrigerator. Discuss storage options with the Project Chemist and document the storage area/conditions.

5.1.2 After opening shipping containers, Chain of Custody (COC) forms and any other documents are located removed, and checked for the presence of short holding time or rush samples. The temperatures of the coolers are measured following the guidelines in section 5.4 of this SOP. The acceptance criterion for properly chilled samples in a cooler is $4 \pm 2°C$. If a cooler exhibits a temperature outside of the acceptance range, or exhibits any other anomalies, the CRF is attached to the Service Request and submitted for review to the appropriate project manager. Samples or coolers which are received outside of the temperature range are noted on the cooler receipt form.

NOTE: EPA drinking water requirements for microbiology samples (surface water treatment rule and coliphage samples) require that samples be at 10°C or less. If the temperature is $>10°C$, the sample results must be flagged by recording the temperature in the "'Remarks" section of the Bacteriological

Analysis Form, or by noting the temperature and flagging requirement on the CRF if the results will be reported on standard forms.

NOTE: Some states or projects may require specific cooling requirements for shipping coolers and special cooler temperature assessment procedures. For example, Wisconsin DNR does not allow the use of blue ice.

5.1.3 Rush requests and samples with short holding times are given priority for initial processing. For samples with extremely limited time remaining before the expiration of the holding time and that are in danger of expiring prior to being able to complete the login process, see 5.1.4.2. Sample containers are removed and organized according to chain of custody identification and analysis. Once unloaded, all SMO staff will finish the login and issuing process for short holding time and rush samples prior to working on the remaining samples. Any containers that are received in broken condition or leaking are documented on the Cooler receipt Form (CRF) and on the chain of custody. The appropriate Project Chemist is also notified. For EPA samples which exhibit discrepancies or are damaged upon receipt, the EPA Project Chemist is responsible to notify EPA SMO for direction.

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Note: Samples received for NCASI Method WP-99.02 must be kept refrigerated or iced in accordance with section 6.3 of the method SOP. Once the samples are identified and verified against the COC, the samples must be placed back in an iced cooler or a refrigerator until login is complete and samples can be relocated to their assigned storage location. **DO NOT DELIVER SAMPLES TO THE LABORATORY**.

5.1.4 Samples received with short or expiring holding times will be issued via a "Temporary Service Request", prior to the final Project Chemist review, enabling the laboratory to quickly access or process the samples. For samples that require wastewater microbiology testing, the analysis is to begin as soon as possible after receipt at the laboratory. Holding times are assigned according to the sample type, test method, and as prescribed in Standard Methods. Microbiology samples received past the holding time do not meet sample acceptance requirements and a notation is made on the Bacteriological Analysis Form and/or Cooler Receipt and Preservation Form. Decisions regarding the disposition of the samples that do not meet sample acceptance criteria are to be documented on the Cooler Receipt and Preservation Form by the Project Chemist.

5.1.4.1 Sample receiving notifies the laboratory of short hold time samples by creating a copy of the service request for each department and stamping with "Temporary". The original service request is stamped with the "Temporary

Service Request/Custody" stamp for signature of receipt by all receiving labs. The appropriate bottles associated with the short hold samples are scanned to either the department (if bottles need to be delivered to the lab) or to the appropriate home location.

NOTE: Samples received for General chemistry with holding times expiring *before* 10am the following day are to be delivered to the laboratory for analysis. All other samples (excluding VOA & foreign soils) are to be scanned to the Short Hold shelf and delivered to that location for easy retrieval by the analyst. VOA and foreign soils are to be scanned to their home location and placed in the appropriate storage areas.

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5.1.4.2 If the holding time is limited and in danger of expiring prior to the completion of the login process, immediately notify the appropriate laboratory via phoning the department or via over-head paging. When notifying the department, indicate the test and the time the holding time is expiring. Immediately notify the appropriate PC via phoning them or via over-head paging. Complete the cooler receipt form noting any discrepancies. Create two copies of the Chain of Custody and stamp one with the "Custody Transfer" stamp. This copy is to remain in SMO. When samples are removed from SMO the chemist signs for custody of the sample(s) noting the time taken. A copy of the COC is made available to the analyst. Analysts must return the original sample to SMO as soon as possible so that the login and labeling process can be completed. Upon returning the sample, the analyst relinquishes custody back to SMO by signing the COC and noting the time returned. SMO takes custody by signing the COC and noting the time.

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5.1.5 For water VOA samples (those received in 40mL VOA vials), inspect the vials for headspace.

5.1.6 Listed below are items which must be verified against the chain of custody information as it applies to samples and containers received:

- Sample identification
- Number of containers received
- Matrix
- Correct bottles for analysis requested.
- Correct/sufficient sample volume for analysis
- Correct preservatives for analysis. The CAS sample bottle preparation form is attached as a reference for proper preservatives.

At this point, a brief evaluation of the amount of sample provided for the requested analyses is made. Compare the sample containers and estimated amount of sample provided to the analyses requested on the COC. Using Table

1, determine if the amount of sample provided is at least as much as the minimum sample amount required. If not, notify the Project Chemist. The Project Chemist should provide further instructions for handling the sample login.

5.1.7 For inorganics analyses on water samples where preservation at a prescribed pH is required, check for the appropriate pH. Refer to Table 2 for those analyses requiring the pH check at the time of receipt. For example, water samples for metals analysis require a pH of <2 and water samples for cyanide analysis require a pH of >12. The pH check is documented on the cooler receipt form which, when completed, is kept with the SDG file. The pH is checked on bottles requiring certain organics analyses, including oil and grease, hydrocarbon, or VOA analyses by the lab department. All pH measurements made by SMO personnel must be performed by pouring a small aliquot of sample from the bottle into a plastic weigh boat. Narrow-range (increments of 0.2 units or less) pH test strips are used. The pH test strips are dipped into the liquid in the weigh boat in order to measure the pH of the sample. Under no circumstances is a pH test strip to be dipped directly into a sample container, due to the possibility of contamination. If further preservation of the sample is needed, the appropriate acid or base is added (up to a maximum of 2mL per liter). The lot number for the preservative added is recorded on the cooler receipt and preservation form as well as the time preserved.

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Note: If acid is added to a metals sample at the time of login, a comment is added to the Service Request indicating to the analyst that the sample was preserved at login. This indicates to the analyst that the 16-hour minimum sample holding requirement listed in the laboratory SOPs applies.

5.1.8 For semivolatile organics analyses on water samples where preservation is necessary for samples with residual chlorine present, check for the presence of residual chlorine (see Table 2 for analyses required). Using a potassium iodide starch test strip, pour a small amount of sample into a weigh boat and dip the strip into the weigh boat. If positive, the test strip will turn purple. Test one bottle per sample and record the result. If the test for residual chlorine is positive, the sample is taken to the laboratory for addition of sodium thiosulfate solution (1mL of 10% to each applicable bottle) and documented. The lot number for the preservative added is recorded on the cooler receipt and preservation form.

5.1.9 Discrepancies and Broken Samples

5.1.9.1 Any discrepancies or concerns from sections 5.1.1 through 5.1.6 above are noted on the COC and/or Cooler Receipt Form and communicated to the Project Chemist. Any resolutions are recorded on the Chain of Custody form, a nonconformity form, or a phone log that is placed in the

service request master file. If a Chain of Custody is not received, information is noted on a CAS Log-In Information sheet (see Appendix).

5.1.9.2When sample identifications on bottles are different than what is on the Chain of Custody, the difference is noted on the Cooler Receipt Form (CRF) and the project chemist is informed, via the "Please Check" Post-it, to check the ID. Once it is logged in on the service request the way the client wants and discrepancies are noted on CRF, a red check is placed on the sample bottle. This informs the lab that the discrepancy has been noted. If there is a discrepancy between the service request identification and the sample bottle identification and no red check is on the sample bottle, the analysts must inform SMO immediately to verify they have the right sample and it can be documented as stated above.

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5.1.9.3 Cleanup procedures are as follows:

Liquids: Broken glass is handled carefully using disposable gloves and disposed of in the Glass Disposal Box. The liquid, including ice, is collected and disposed of as RCRA waste. Any absorbent packing material containing the liquid is collected and disposed of in the RCRA solids waste container.

Soils: Broken glass is handled carefully using disposable gloves and disposed of in the Glass Disposal Box. The solids are collected and disposed of in the RCRA solids waste container along with any packing material contaminated with the sample.

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5.1.9.4For VOA samples in VOA vials, EPA Method 5030B states that the size of any bubble caused by degassing upon cooling should not exceed 5-6mm. The presence of air bubble(s) is noted on the CRF if the bubble is $\geq$ 5mm (approximately the size of a small pea). If a bubble this size is present, the cap and septum should be inspected for breakage or leakage. The Project Chemist will be notified if no other vials for the sample can be used (all vials have bubbles).

5.1.10 For EPA CLP work, the following additional steps must be taken:

5.1.10.1Designated Sample Custodian

The SMO department must designate a primary sample custodian who is responsible for the log-in of EPA CLP samples. An alternate representative should also be designated; the EPA PC should be aware of the identity of these people and should be notified if there is a desire to transfer this authority to a different individual.

5.1.10.2Sample Log-In Sheet (DC-1)

This form is used to document receipt and inspection of samples and containers. A DC-1 form (see Appendix) is required for each cooler. It must be completed as the cooler is opened and samples are examined, as described in the applicable CLP SOW. In addition to examining the items found in section 5 of this SOP, the following additional items must be reviewed and/or noted on form DC-1:

- The presence/absence and condition of custody seals.
- The presence/absence of chain-of-custody forms, airbills or airbill stickers, traffic reports or packing lists, and sample tags.
- Custody seal numbers when present
- Airbill or airbill sticker numbers
- Sample tags listed/not listed on the COC records
- Date and Time of receipt
- EPA sample numbers
- Sample tag numbers

When the DC-1 form is completed, the sample custodian or designated alternate must provide a full signature sign-off on the report; initials are not acceptable.

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5.1.10.3pH Verification - Check the pH as described in section 5.1.6. Any discrepancy from this must be reported to EPA SMO.

5.1.10.4Sample Traffic Reports

A traffic report is required for each Sample Delivery Group. Traffic reports and an SDG cover sheet must be sent to SMO within three days of receipt of the last sample in SDG, as described in the applicable CLP SOW.

5.1.10.5SDG Naming

For EPA CLP work, the following rules must be followed in forming Sample Delivery Groups (SDG). An SDG is defined by the following, whichever is more frequent:

- Each case of field samples, or
- Each 20 field samples in a case, or
- Each 14 calendar day period during which field samples in a case are received. The 14-day period begins with the receipt of the first sample.

The SDG number is the 6-digit EPA sample number of the first sample received in an SDG. When several samples are received at the same time, the lowest alpha, numeric number is used. CAS assigns a unique lab code to each sample. The lab codes are recorded on the Chain of Custody where it is applicable.

5.1.11 Samples received after normal business hours (8-5 Monday – Friday and 8-12 on Saturday) are stored in a cooler in an appropriate refrigerator and are fully processed the following day. Upon receipt, an After Hours Receipt Form is completed and the temperature of the cooler is recorded in accordance with section 5.4 of this SOP (Note: the temperature must be recorded from the temperature blank if one is present). If samples are received the same day they are collected they can be placed in appropriate cold storage without determining cooler temperatures (In this case, samples are considered acceptable if there is evidence that the chilling process has begun and they do not need to meet the criteria of being within 2° C of the required temperature). The location of storage is noted on the After Hours Receipt Form (i.e. Samson, Herk, etc.).

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5.1.12 The chain of custody form will be signed when the log-in procedure is completed (on the next working day if the samples are received after hours).

5.1.13 Courier Service

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CAS provides a Courier Service for our Clients from our Kelso Laboratory Southbound to the Portland Metropolitan area to pick up samples. When picking up samples from Clients, a Courier/After-Hours Sample Receipt Record is filled out and signed by our Courier and also by the Client/Sampler. Information such as date & time of pick-up, the Company name, number of containers, project number and if custody seals were present or added are noted on this Receipt Form. The Courier retains a copy of the Courier/After-Hours Sample Receipt Record and this copy is placed in the Master File once the job is logged into the LIMS system in the laboratory. The original copy is given to the Client at the time the CAS Courier takes possession of the samples.

5.2 Sample Login

5.2.1 Each job received at the laboratory is logged into the Laboratory Information Management System (LIMS). Access to LIMS Login is limited to Sample Management Staff and Project Chemists. The LIMS will assign the next available Service Request number. The Service Request number is made up to identify the CAS lab, the year and then a numeric number (i.e. K0502250: K for the Kelso lab, 05 for the year and then 02250 would be the next number available in the system).

5.2.2 The client and project are identified in the LIMS based on the COC information. The Sample Delivery Group (SDG) sample template is chosen and transferred to the login. If needed, the requested tests are added. The sample identifications, date and time of collection, and date received are entered. The date on which the laboratory takes possession of the samples is defined as the date the COC is signed. For after-hours sample receipt where the after hours receipt form is used, the COC is not signed until the next business day (see 5.1.11). If the collection time is not provided, a conservative estimate of the time is made. In cases where the client and project information is not in LIMS, the PC is contacted to setup the project or give instruction to the SMO staff as to how to set up the project.

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5.2.3 Each test is automatically assigned a container ID in LIMS. The specific containers received are reconciled at the time of login.

5.2.4 The service request report is printed and a master Service Request File is created. Another person in the Sample Management group performs a login review. The master SR file is then given to the Project Chemist for final review before being issued to the laboratories. The Project Chemist reviews the service request form before being issued to the analysts. For analyses with short holding times (generally 48 hours and less), other samples near holding time expiration, and RUSH samples (due within 5 days), a "Temporary Service Request" is issued directly to the applicable department, whose representative signs off on receipt of the service request. SMO also prints a "2-day report" from LIMS that identifies all analyses with holding times expiring within 2 days and due dates within 2 days.

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5.2.5 Lab Codes and Sample Identification/Labeling

Each sample is given a unique sample lab code by the LIMS system. This number is designated by the service request number, followed by a dash, a sequential number, a period and a container ID (e.g. K0504567-001.01), where K0504567 represents the service request number, -001 represents the sample and .001 represents the container. Thus, each sample is given a unique ID. Samples are reviewed to make sure the lab codes match the correct sample identification on the service request and that correct bottles were received for the analyses.

5.2.6 Solid Samples Labeling

5.2.6.1If the quantity of sample given to the laboratory is insufficient for the analyses requested, the sample container should be labeled with Limited Sample Quantity (or something similar) or attach a "LIMITED SAMPLE VOLUME" tag. The project chemist will set the priorities for the analyses and, if possible, estimate the quantity of sample to be used for

each test. This information should be documented and communicated to the lab via a Form V. For example, 8081 use 10 g; metals use 1 g; TCLP use 20 g.

NOTE. Samples that are quantity limited and require multiple analyses from a single container must be identified as soon as possible. Optimally, this should happen during sample login; however, discovery at any time should follow the same process. When it is discovered that a sample is quantity limited, the quantity of wet sample available is estimated and the project chemist is immediately notified. The project chemist should attempt to prioritize the tests most critical to the client (*i.e.*, which test should be performed first) and estimate the sample quantity allotted to each test.

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5.2.6.2 Solid Samples Requiring VOC and Non-VOC Analyses with One Container

When only one container is received and both VOC and non-VOC analyses are requested, SMO will attach a "VOA FIRST" tag to the jar and indicate the tests required.

The VOC department will remove a sample aliquot first for the VOC analyses. The VOC department will handle the sample as if it were a Rush analysis, so that the other non-VOC analyses will not be unduly delayed. The VOC chemist who opens the container will initial and date the "VOA FIRST" tag next to the appropriate test. A ***VOC Analysis First*** note will also be included on the SR.

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Sample aliquots for non-VOC analyses may not be taken from the sample container until the aliquot for the VOC analyses has been removed. Once the aliquot for the VOC analyses has been taken from the sample container, sample aliquots for the non-VOC analyses can be removed as prescribed in the various applicable analytical SOPs.

5.2.6.3 For solid samples requiring VOC and Non-VOC analyses with multiple containers, one of the sample containers will be designated for VOC analyses by either placing a custody seal or a "VOA FIRST" tag on the container.

5.3 Login Review

5.3.1 A peer review of the login and newly generated Service Request (SR) is done by the SMO staff. The SR is compared to the chain-of-custody to ensure that correct and complete information is entered on the SR. Refer to the SMO Login Review sheet (see Appendix).

In some cases (i.e. more complex projects) and at the Project Chemist's discretion, the SMO peer review may be performed by the Project Chemist. In this case, the review of the folder is documented by the Project Chemist when updating LIMS and/or initialing the service request.

5.3.2 As mentioned in section 5.2.3 above, the Project Chemist performs a final review of the login. At a minimum, this must include a close examination of the SR and chain-of-custody to verify that the SR generated by SMO accurately reflects the specifications for the project and samples. The Project Chemist may also need to refer to other project-related information, such as project QAPPs, client communication records, etc. If the SR does not accurately specify the work requirements, is incorrect, or is incomplete, the Project Chemist makes the needed changes and the draft SR file returned to SMO for revision. Once the SR is correct, the Project Chemist documents the review by signing the original SR.

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5.4 Thermometer calibration and temperature measurement

5.4.1 The QA department performs thermometer calibration on all thermometers used to monitor sample storage temperature (see SOP ADM-SEMC). Each storage thermometer is given a unique numerical identification tag if one does not already exist, and all records of calibration are kept in the thermometer calibration notebook. The correction factor is recorded on the thermometer label.

5.4.2 Temperature measurement is performed for coolers using calibrated digital thermometers. The thermometer is plunged into the packing material, if possible, or placed as deep into the cooler as is practical and the lid closed. When coolers are packed such that samples are isolated from the main cooler compartment, via plastic bag and/or insulation (foam, vermiculite, etc.), place the thermometer down into the sample area. When multiple samples are in one large bag, place the thermometer in the bag. Do not just place thermometer on top of the bag or insulating material. The equilibration time is a minimum of 10 minutes.

5.4.3 The correction factor is applied to the temperature given by the thermometer after a measurement, and it is the corrected temperature that is recorded on the CRF. As an example, if the correction factor is -0.5, and the thermometer reads 5.9°C, then the corrected temperature is 5.4°C. If a temperature blank is present, the same thermometer is used to read the temperature blank when the cooler is unpacked. After measurement of the temperatures, all of the information is recorded in the appropriate space on the cooler receipt form.

Note: A temperature blank is generally considered more indicative of sample temperature inside the cooler. Where a temperature blank is present, its temperature reading is considered the *primary* temperature of the cooler and the

second reading obtained from the thermometer placed in the cooler is for additional information.

5.5 Sample Storage, Security, and Internal COC

5.5.1 There are a number of refrigerators, freezers, and room temperature storage areas dedicated to specific storage requirements (e.g. Water VOCs, Soil VOCs, etc...) All of the sample storage facilities are located in the secured area. Samples are held in refrigerators until analysis is completed and reported to the client. Refrigeration of all non-tissue samples is maintained at a temperature of 4 ± 2° C unless otherwise specified by the state, project, or client specific protocols. Exception: Soil and sediment sample for designated for mercury analysis by EPA Method 1631 are stored frozen upon receipt. Tissue samples are stored in freezers at -16 to -24° C. Room temperature sample storage is specified in some cases.

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Note: If a new or moved storage unit is to be placed in service, QA must be notified before using it so it can be monitored for acceptable conditions. QA will document and approve the unit for use prior to using for sample storage. Once SMO is notified, QA will begin regular monitoring.

5.5.2 When samples are labeled accordingly with lab codes, they are placed in appropriate refrigerators in a secured area. This area is secured with combination locks which can be accessed by technical laboratory personnel, project managers, administrative support personnel and all senior staff members. Location of samples is recorded on the Service Request form and in internal COC records.

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5.5.3 Internal COC procedures for checking samples in and out are described in the SOP SMO-SCOC *Sample Tracking and Laboratory Chain of Custody*. The SMO department has a Sample Custodian who is responsible for retrieving/returning samples from/to storage for analysts. The Sample Custodian checks the samples back into custody/storage. See the SOP SMO-SCOC for specific guidance.

5.5.4 As an alternative to the Sample Custodian sample retrieval system, analysts may retrieve and check samples out/in directly themselves.

NOTE: Regardless of which procedure is used, the analyst is responsible for taking custody of the sample in LIMS, ensuring the internal chain of custody of samples is accurately documented. It is also the responsibility of the analyst to return samples to the storage area when work is completed, and relinquishing custody in LIMS.

5.5.5 When a soil or sediment sample jar is broken during sample storage a determination has to be made whether or not the sample is salvageable (i.e. whether or not the sample has been completely compromised). If there is any question in determining whether a sample is completely compromised contact the PC. If a tissue sample is broken during storage immediately contact the PC for direction.

5.5.5.1 If some or the entire sample is salvageable scan the broken bottle as "broken" in LIMS. Transfer the sample to a new container (if unsure of the transfer process or there are concerns with contamination, contact the PC or appropriate laboratory department supervisor) and assign a new container ID to the sample in LIMS. Label the new container with a barcode label.

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5.5.5.2 If the sample is not salvageable notify the PC and determine if there is additional sample available for analysis. Scan the broken bottle as "broken" in LIMS and dispose of the sample in the appropriate waste stream (if hazards cannot be determined at the time the sample is lost, place it in a ziplock baggie, label it, and place it on pre-disposal shelf for later determination).

5.5.6 Once the Analytical Report has been mailed to the client, the Internal Chain of Custody record from the bar-coding system database is printed and retained in the Service Request File.

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5.6 Sample Disposal

After all analyses have been completed and the Certified Analytical Report (CAR) has been generated and mailed to the client, the associated samples are pulled from refrigeration and stored on shelves located in the secure storeroom area. An assessment is made of the nature of the samples (i.e. hazardous or non-hazardous) and the samples disposed of accordingly. Water samples are held for 31 days and soil samples for 2 months unless contractual obligations supersede these parameters. Fish and invertebrate animal tissue samples are held at -20°C for 90 days after reporting. After the holding period has expired, samples are disposed of using appropriate disposal procedures provided by the health and safety officer and/or committee. This task is performed by qualified SMO personnel.

5.7 Sample Shipping to Outside Labs

5.7.1 The sample is logged in and the specific product code, or "misc. outside", is used for subcontracted analysis. A list of routinely subcontracted analyses is attached.

5.7.2 For CAS Network Labs using LIMS, the samples are shipped with a chain of custody indicating the analyses to be performed.

5.7.3 For other labs, a purchase order (if non CAS lab) and chain of custody is filled out for work going to another subcontract laboratory. TAT, deliverables,etc. are specified. Prior to shipment, SMO personnel perform a review of the COC against samples subcontracted. Samples to be shipped to an outside lab are stored in a refrigerator near SMO.

5.7.4 A shipping form is completed by SMO and given to the shipping department for shipment.

5.7.5 Samples are prepared for shipping by the shipping department by packing in the appropriate packing material, placing blue ice, samples, and the chain of custody in shipping coolers. Custody seals are signed and dated and placed on the front and/or side of the cooler. The cooler is then sealed with packaging tape. A "Sample" label is placed on the cooler.

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5.7.6 Samples that are relinquished to another laboratory that reports all of their data directly to the client and bills the client directly do not need to be logged in.

6. RECORDS

All sample receipt records, including COC forms, CRFs, Service Requests, sample information, etc. is filed in the master service request file.

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7. CHANGES IN SOP SINCE THE LAST REVISION

7.1 Sec 5.1.2 Added statement to check for sort holds time or rush samples.
7.2 Sec 5.1.2 Removed statement - For WDNR, it should be noted if regular ice was present in the cooler.
7.3 Sec 5.1.3 added language to clarify how to handle short HT samples.
7.4 Sec 5.1.4.1 Added language to clarify how to handle short HT samples.
7.5 Sec 5.1.4.2 Added language to clarify how to handle short HT samples.
7.6 Sec 5.1.7 Added requirement to record the time preserved.
7.7 Sec 5.1.9.7 Removed sentence - For method 1631 samples, inspects the sample for the presence of headspace. Document on the CRF if present.
7.8 Sec 5.5.3 Referenced SMO-SCOC SOP
7.9 Sec 5.5.5 Added procedure to follow when container is broken in the lab.
7.10 Sec 5.4.1 Corrected SOP name.

Table 1

Minimum Sample Volume Requirements

Measurement	Matrix	
Inorganics	**Water (ml)**	**Soil (g)**
Color	50	--
Conductance	100	10
Hardness	100	--
pH	50	50
TSS	200	--
TDS	100	--
TS	100	10
TVS	100	10
Settleable Solids	1000	--
Turbidity	100	--
Total Metals	100	10
Metals w/reductive ppt.	1000	--
Dissolved Metals	100	--
Acidity	100	--
Alkalinity	100	--
Bromide	50	10
Chloride	50	10
Cyanide	500	10
Fluoride	50	10
Ammonia as N	50	10
TKN	500	10
Nitrate+Nitrite	100	10
Nitrate	50	10
Nitrite	50	10
Orthophosphorus	100	10
Total Phosphate	100	10
Sulfate	50	10
Sulfide	500	25
Sulfite	500	--
BOD	1000	50
COD	50	25
TOC	50	25
Total Phenols	500	25
MBAS	500	--
AOX/TOX	500	--

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Table 1

Minimum Sample Volume Requirements (continued)

Measurement	Matrix	
Organics	**Water (ml)**	**Soil (g)**
Oil and Grease	1000	25
DRO	500	30
Pesticides (8081A,8141)	1000	30
PCP (8151M)	40	30
PCBs (8082)	1000	30
PAHs (8270C, 8310)	1000	30
Semivolatiles (8270)	1000	30
GRO	2-40ml vials	30
BTEX (8021B)	2-40ml vials	30
Volatiles (8260B)	2-40ml vials	30
Dioxins	1000	30

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Table 2

Sample Preservation Requirements

Inorganics pH Requirements

Analysis	Preservation requirement (pH)
Metals (total) except CrVI and Hg	<2
TOC	<2
COD	<2
Ammonia	<2
TKN	<2
Total Phosphorus	<2
Nitrate/Nitrite	<2
Sulfide	>9
Cyanide	>12
TOX/AOX	<2

Semivolatile Organics Residual Chlorine Requirements

Analysis	Requirement
Semivolatile Organics (625 and 8270)	None present
Organochlorine Pesticides (608 and 8081)	None present
Herbicides (8151)	None present

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Appendix

Cooler Receipt and Preservation Form
Login Information Sheet
DC-1 Form
SMO Login Review Form
Procedure for Salvaging Broken Samples

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Initial Login Review ☐ Revision Review ☐

Check the following information before the sample containers are shelved:

	Y	N	Is the CRF completed? (resolutions noted, etc.)
	Y	N	Are all bottles correctly labeled? (Client name vs. Lab code & number)
	Y	N	Is the Matrix consistent with the Chain of Custody (COC) and the bottles?
	Y	N	Are bottles labeled with the correct shelf number?
NA	Y	N	If indicated on the COC, are samples designated for QC specified on the SR?

Reviewed By:_____ Date:_____

Check the following information on the service request against the information on the COC:

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NA	Y	N	Are sample names spelled correctly on the service request (SR)?
NA	Y	N	Is the date collected for each sample correct on the SR?
NA	Y	N	Is the date received correct on the SR? Multiple dates received?
NA	Y	N	Is the project name correct (as listed on the COC)? Discrepancies noted?
NA	Y	N	Is the project number correct (as listed on the COC)? Discrepancies noted?
NA	Y	N	Is the Tier level correct (as listed on the COC)? Discrepancies noted?
NA	Y	N	If listed on the COC, is the PO Number correct on the SR?
NA	Y	N	Are all the samples indicated on the COC logged in?
NA	Y	N	Are all analyses indicated on the COC logged in?
NA	Y	N	For RUSH TAT, does the due date listed on the SR make sense? Is the Rush flag flipped?
NA	Y	N	If any, are the pertinent comments on the COC indicated on the SR? (i.e. metals lists, volume limitations, hazards, etc.)
NA	Y	N	Has a temporary SR been issued for short hold-times and/or 24-48hr rushes?
NA	Y	N	If preservative was added upon receipt, is it indicated on the SR?
NA	Y	N	Does the SR contain appropriate additional product codes such as: EDD-DOD, Sample Prep, Filter codes, TS-Met?
NA	Y	N	Is the two- Day report printed?
NA	Y	N	If needed, is the Sub-Chain printed for outside shipping?
NA	Y	N	Is the COC signed by SMO?

Reviewed By:_____ Date: _____

Columbia Analytical Services, Inc. PC_____

Cooler Receipt and Preservation Form

Client / Project:_____ Service Request ***K09***_____

Received:_____ Opened:_____ By:_____

1. Samples were received via? ***US Mail*** ***Fed Ex*** ***UPS*** ***DHL*** ***GH*** ***GS*** ***PDX*** ***Courier*** ***Hand Delivered***
2. Samples were received in: (circle) ***Cooler*** ***Box*** ***Envelope*** ***Other***_____ ***NA***
3. Were custody seals on coolers? NA Y N If yes, how many and where?_____
   If present, were custody seals intact? Y N If present, were they signed and dated? Y N
4. Is shipper's air-bill filed? If not, record air-bill number:_____ NA Y N
   _____ _____ _____
5. **Temperature of cooler(s) upon receipt (°C):** _____ _____ _____ _____
   Temperature Blank (°C): _____ _____ _____ _____
   Thermometer ID: _____ _____ _____ _____
6. If applicable, list Chain of Custody Numbers: _____ _____ _____ _____
7. Packing material used. ***Inserts*** ***Baggies*** ***Bubble Wrap*** ***Gel Packs*** ***Wet Ice*** ***Sleeves*** ***Other***_____
8. Were custody papers properly filled out (ink, signed, etc.)? NA Y N
9. **Did all bottles arrive in good condition (unbroken)?** *Indicate in the table below.* NA Y N
10. Were all sample labels complete (i.e analysis, preservation, etc.)? NA Y N
11. Did all sample labels and tags agree with custody papers? *Indicate in the table below* NA Y N
12. **Were appropriate bottles/containers and volumes received for the tests indicated?** NA Y N
13. Were the pH-preserved bottles tested* received at the appropriate pH? *Indicate in the table below* NA Y N
14. Were VOA vials received without headspace? *Indicate in the table below.* NA Y N
15. **Are CWA Microbiology samples received with >1/2 the 24hr. hold time remaining from collection?** NA Y N
16. Was C12/Res negative? NA Y N

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Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Sample ID	Bottle Count Bottle Type	Out of Temp	Head-space	Broke	pH	Reagent	Volume added	Reagent Lot Number	Initials	Time

**Does not include all pH preserved sample aliquots received. See sample receiving SOP (SMO-GEN).*

Additional Notes, Discrepancies, & Resolutions:_____

Columbia Analytical Services Inc.
Cooler Receipt and Preservation Form

Client / Project:_____ Service Request ***K09***_____

Sample ID on Bottle	Sample ID on COC	Sample ID on Bottle	Sample ID on COC

Sample ID	Bottle Count Bottle Type	Out of Temp	Head-space	Broke	pH	Reagent	Volume added	Reagent Lot Number	Initials	Time

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Additional Notes, Discrepancies & Resolutions:_____

STANDARD OPERATING PROCEDURE

for

SAMPLE TRACKING AND INTERNAL CHAIN-OF-CUSTODY

SOP No.: SMO-SCOC

UNCONTROLLED

Revision: 12

April 23, 2009

Approved By: _____ 4/24/09
Supervisor Date

Julie Goh _____ 4/24/09
QA Manager Date

COPY

_____ 4/27/09
Laboratory Manager Date

COLUMBIA ANALYTICAL SERVICES, INC.
1317 South 13th Avenue
Kelso, Washington 98626

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Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date: _____

SAMPLE TRACKING AND INTERNAL CHAIN-OF-CUSTODY

1. PURPOSE

The purpose of this procedure is to maintain and document internal chain-of-custody (COC) of samples. Custody documentation must be maintained through all phases of analysis - from sample receipt and initial storage to analysis and disposal.

2. APPLICABILITY

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The procedure is applicable to all field samples, subsamples, and sample extracts and sample digestates as described in the procedure section.

3. DEFINITIONS

3.1. Custody - The guardianship or safe keeping of a sample. A sample is considered to be in a person's custody if it is physically in their possession, or it is in their view after being in their possession, or it was in their possession and then locked up or sealed to prevent tampering, or it is in a secure area.

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3.2. Chain of Custody - The documented order or sequence of the persons having custody of a sample. Chain of custody requires that the sample be in custody of some known person from the time it is collected until it is disposed.

3.3. Custody record - External or internal COC document that clearly defines and documents who is/was in possession of a sample at a given time.

3.4. Login - The SMO process of accepting the sample, inspecting, and entering the sample information into the laboratory LIMS system.

3.5. Sample custodian – The sample management office (SMO) is considered to be the sample custodian for any period of time from sample receipt to sample disposal that the sample is not internally signed into custody by analytical personnel.

3.6. Sample tracking - Identifying or reproducing the path of sample custody throughout the laboratory.

4. DISCUSSION

Chain of custody is the protocol that provides a record of the persons having control of and access to a sample. If the analytical results are questioned the chain of custody documentation is the record that proves the sample was collected and handled according to specification and the sample can be directly linked to the analytical results. This is especially important if the analytical results are questioned or to be used in supporting legal proceedings.

5. RESPONSIBILITIES

5.1 It is the responsibility of sample custodians and laboratory staff to make sure that the procedures described in this SOP are followed and that chain of custody records are complete and accurate. Every appropriate laboratory staff member will be required to familiarize themselves with the procedures listed in this SOP. Once the SOP has been read, appropriate supervisory personnel and section managers must ensure that personnel will comply with the procedures listed herein.

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5.1.1. **Sample Custodian Responsibilities:** It is the responsibility of the Sample Custodian to fill sample requests by the time indicated by the analyst. Once the samples are gathered SMO will transfer custody and deliver the samples directly to the requestor. Upon return of the samples (within designated business hours) from the analyst, it is the responsibility of SMO to scan the samples back into their home storage location and re-shelve them. Samples returned after hours the previous day are to be shelved to their designated shelves by the sample custodians.

5.1.2. **Analyst Responsibilities:** It is the responsibility of the analyst to provide sufficient time for sample requests to be filled by the Sample Custodians. It is the responsibility of the analyst to take custody in the LIMS system as soon as they take samples from a storage location. Upon completing their work, samples must be returned to the sample storage room as soon as possible to minimize the amount of time samples are held at room temperature.

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6. PROCEDURES

6.1. Field sample custody

6.1.1. Sample containers are labeled with a bar-code to identify, and track field samples throughout the laboratory. The bar-coding system uses CAS LIMS database for sample information. The sample tracking process in the laboratory begins with receipt of samples into the laboratory facility. Sample receipt, login, identification, labeling, and storage procedures are all described in the SOP SMO-GEN *Sample Receiving*. Sample receiving personnel will enter the sample information (Service Request number, unique container ID) for each project into the sample database. Following login, the samples are placed in the appropriate refrigerator(s).

6.1.2. Access to all samples is controlled. Samples are stored in a secure, keypad-locked room or in separate locked storage areas. While in these secured and locked storage

areas, the samples are considered to be in the custody of the sample management office (sample custodian). Removal of any sample from the SMO sample storage areas represents a physical change of custody and therefore must be documented via a chain of custody record. It is at this point that internal tracking of the samples is initiated.

Note: All solid samples pulled from a freezer must be placed in a Ziploc storage bag to prevent loss of sample in the event that the jar cracks during thawing.

6.2. Requesting Samples through the Sample Custodian

6.2.1. Open the sample request window by clicking on "Sample Requests" under the "Chain of Custody" heading. Click the "Add Request" button.

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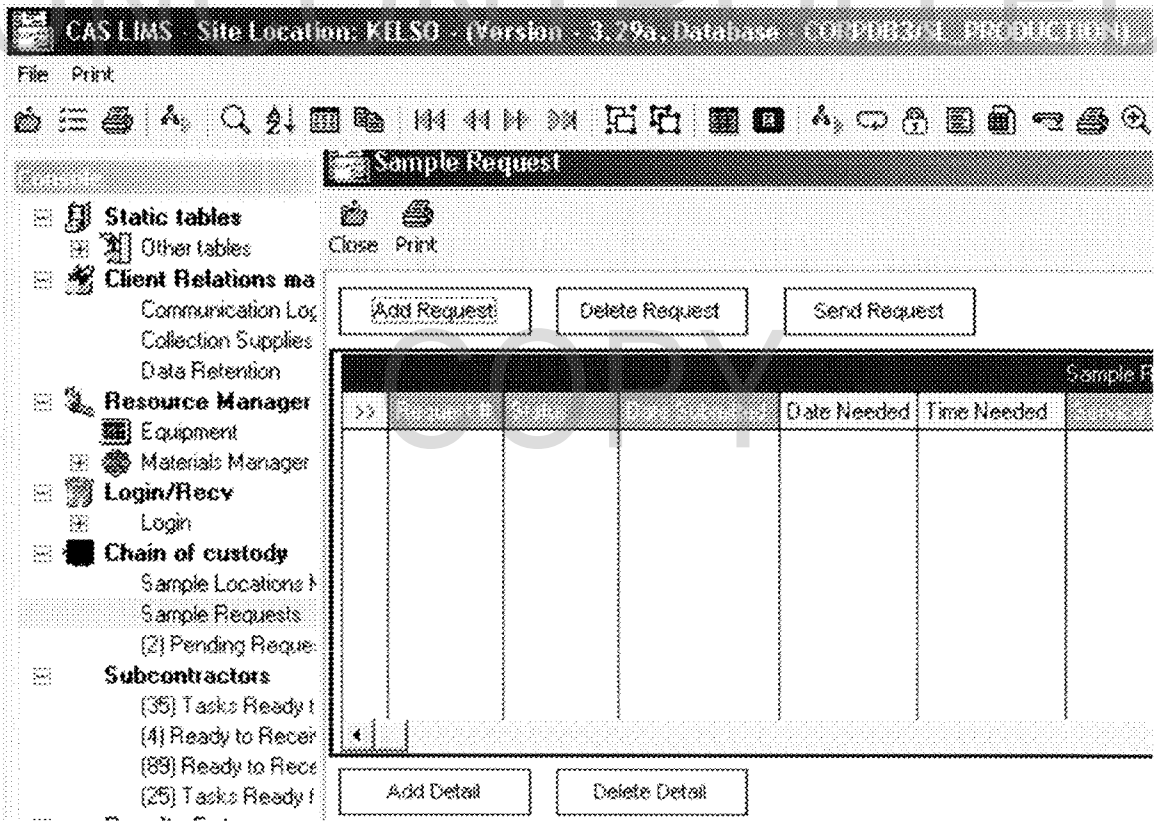
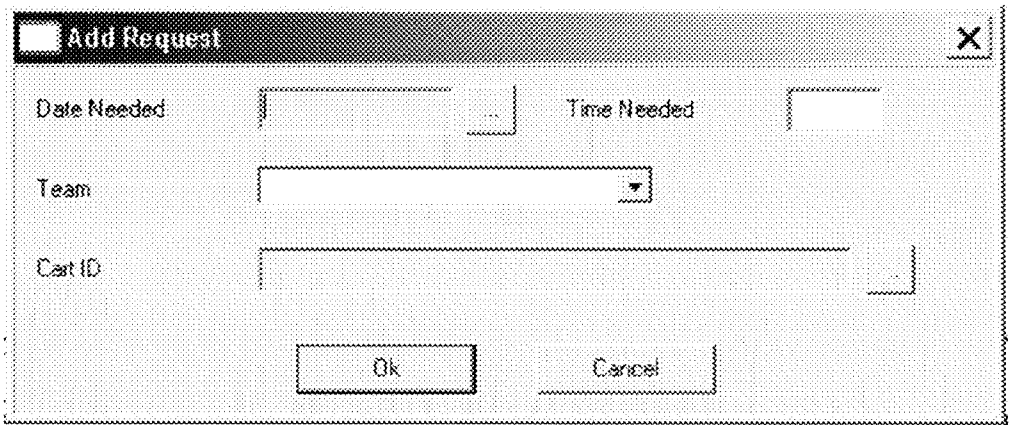


6.2.2. Enter the necessary information in the Add Request window and click OK.



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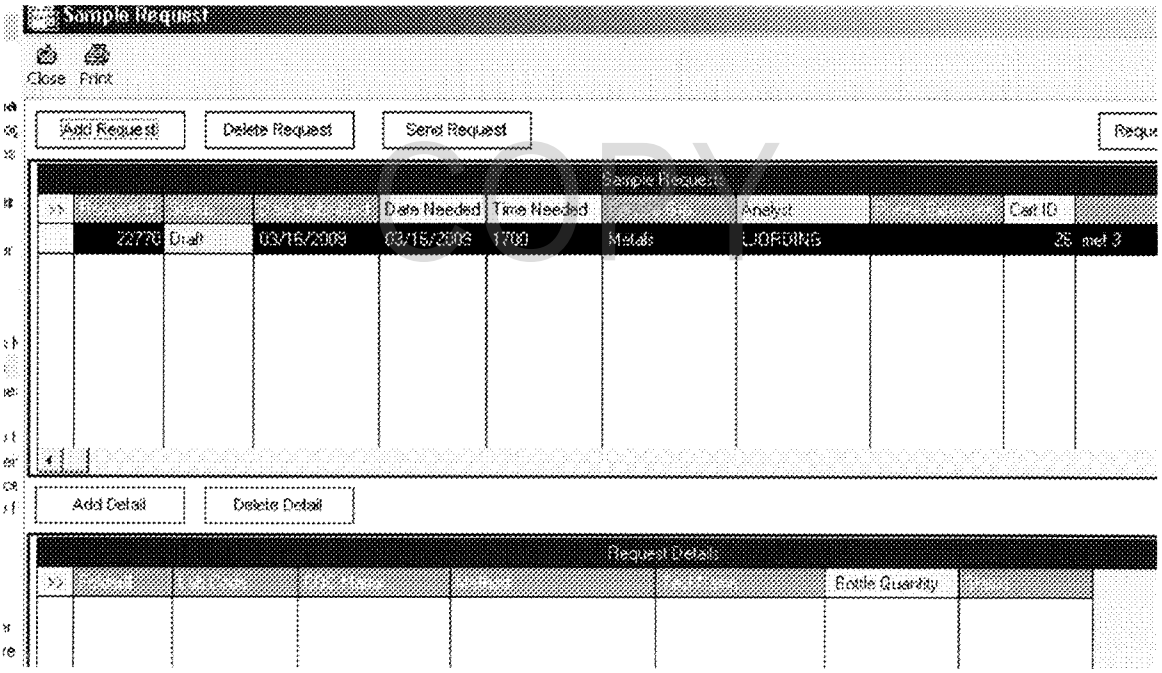
6.2.3. The sample request screen will appear with the basic information as seen below. To add samples to the request click on the "Add Detail" button.



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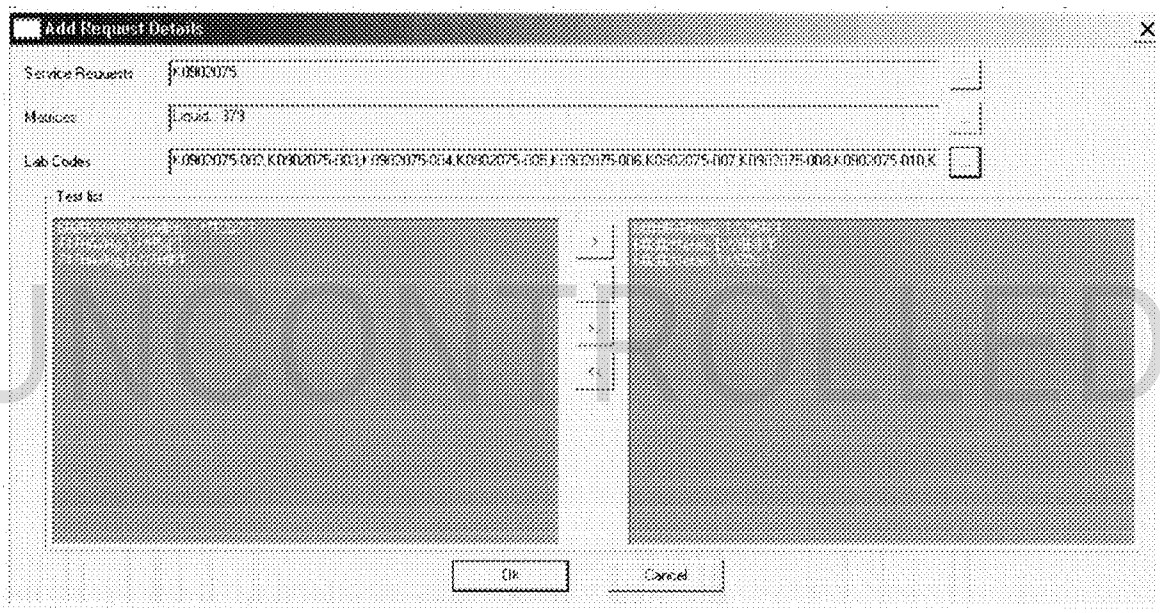
6.2.4. Fill in the details (Service Requests, Matrices, Lab Codes) and select the tests by highlighting and moving them to the right in the Test List box. Click OK.



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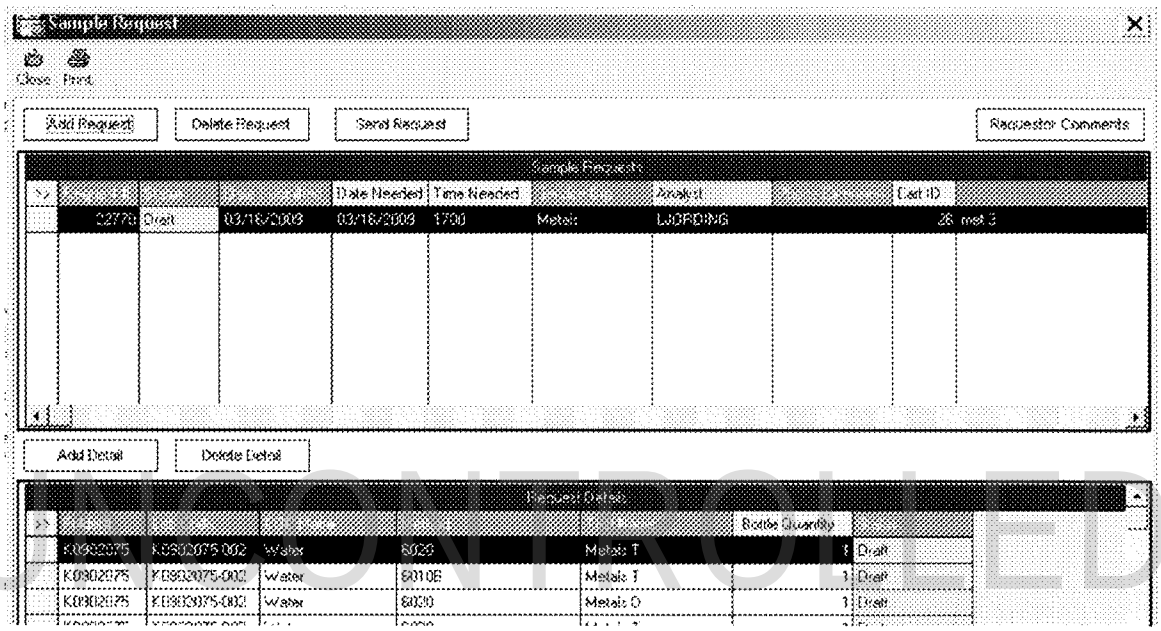
6.2.5. Once all of the samples have been added to the sample request, add any additional information to the request in the "Requestor Comments" field. (Additional information may include things like specific containers needed, extra volume necessary for QC on a given sample, etc.) Once the request is complete click the "Send Request" button.

Note: If one of your team members will be taking possession of the samples (i.e. a swing shift team member completes the sample request form but a day crew person will be taking custody of them to begin the testing) double click on the "analyst" field and change it to the person to whom the samples should be delivered and custody given to.



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6.3. The steps to be taken to by SMO to fill a sample request.

6.3.1. Under Chain of Custody open up the Pending Requests folder and double click the request. The following screen will appear showing the requested list of samples, who requested them, and the date and time they are needed. Print the request and retrieve the necessary samples.

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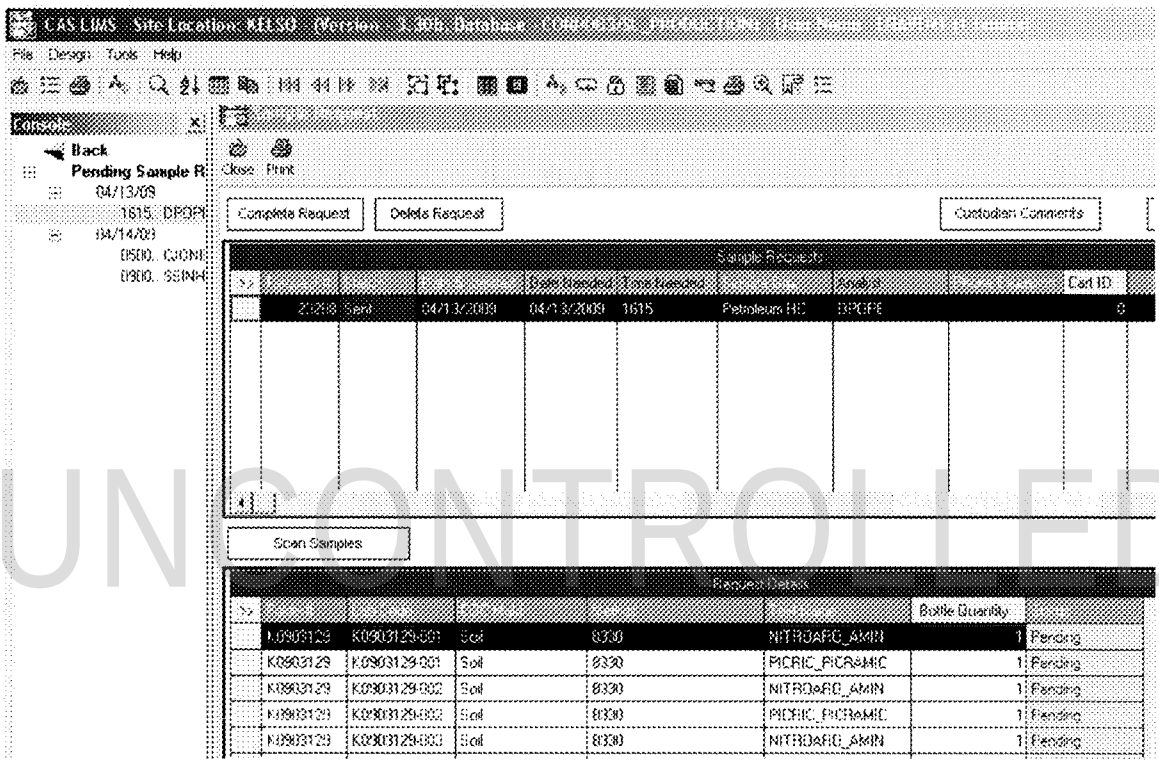

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6.3.2. Click on the Scan Samples button and scan each individual bottle. When all bottles are scanned in click the cancel button. Review the order to see if any bottles were missed. If the samples are not ready to be delivered do not complete the order. Place the order in the appropriate refrigerator for delivery at the appropriate time. If the order is ready to go to the analyst, complete the order by clicking the "complete request" button and click "Yes".

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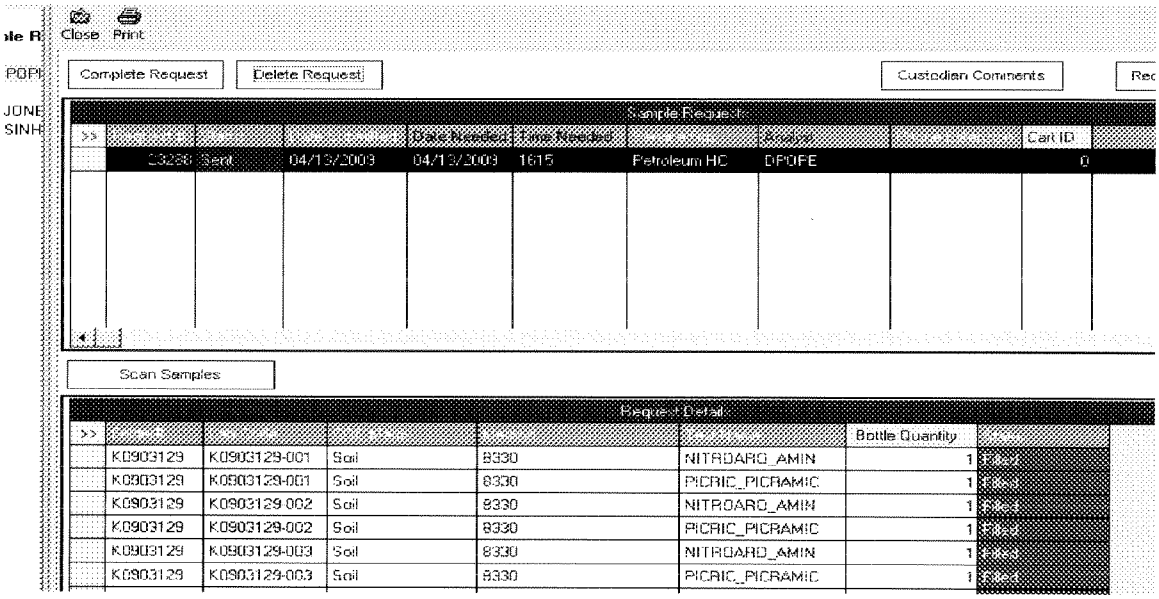
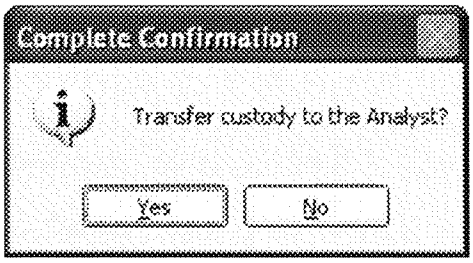


6.3.3. To finish the order and transfer the custody to the requesting analyst, click "Yes".



6.3.4. Deliver the samples to the analyst who now has custody of them.

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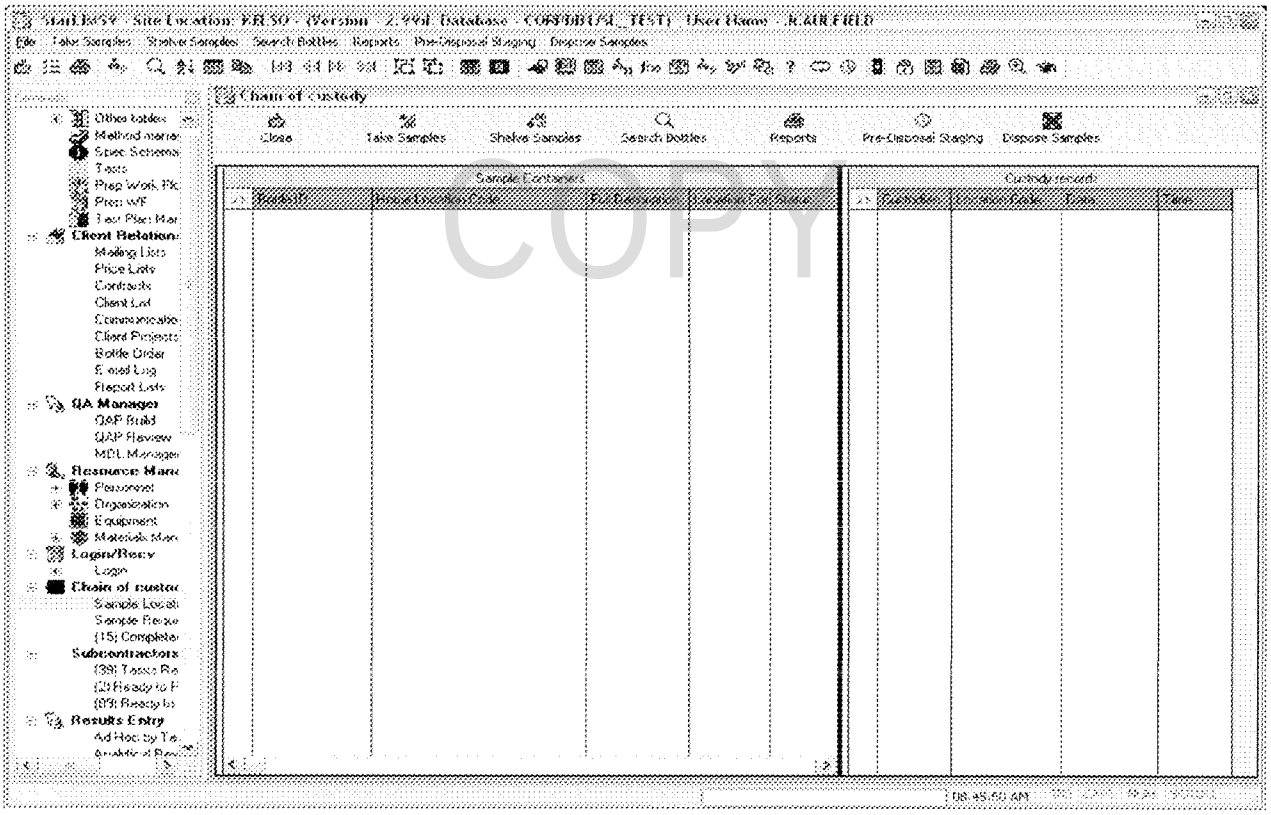
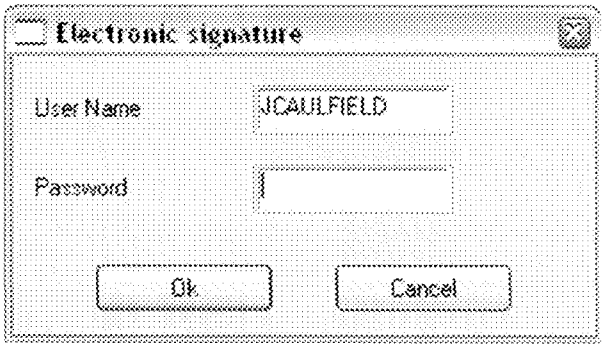
6.4. The steps to be taken to take custody of samples retrieved by an analyst are outlined below:

6.4.1. The main menu display on the internal custody workstation appears as follows:



6.4.2. Choose Take Samples. The following Signature window will appear:



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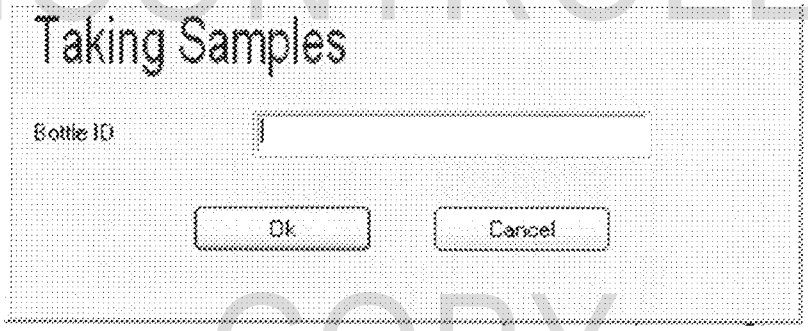
6.4.3. Select name from employee list. The Taking Samples screen will appear next.



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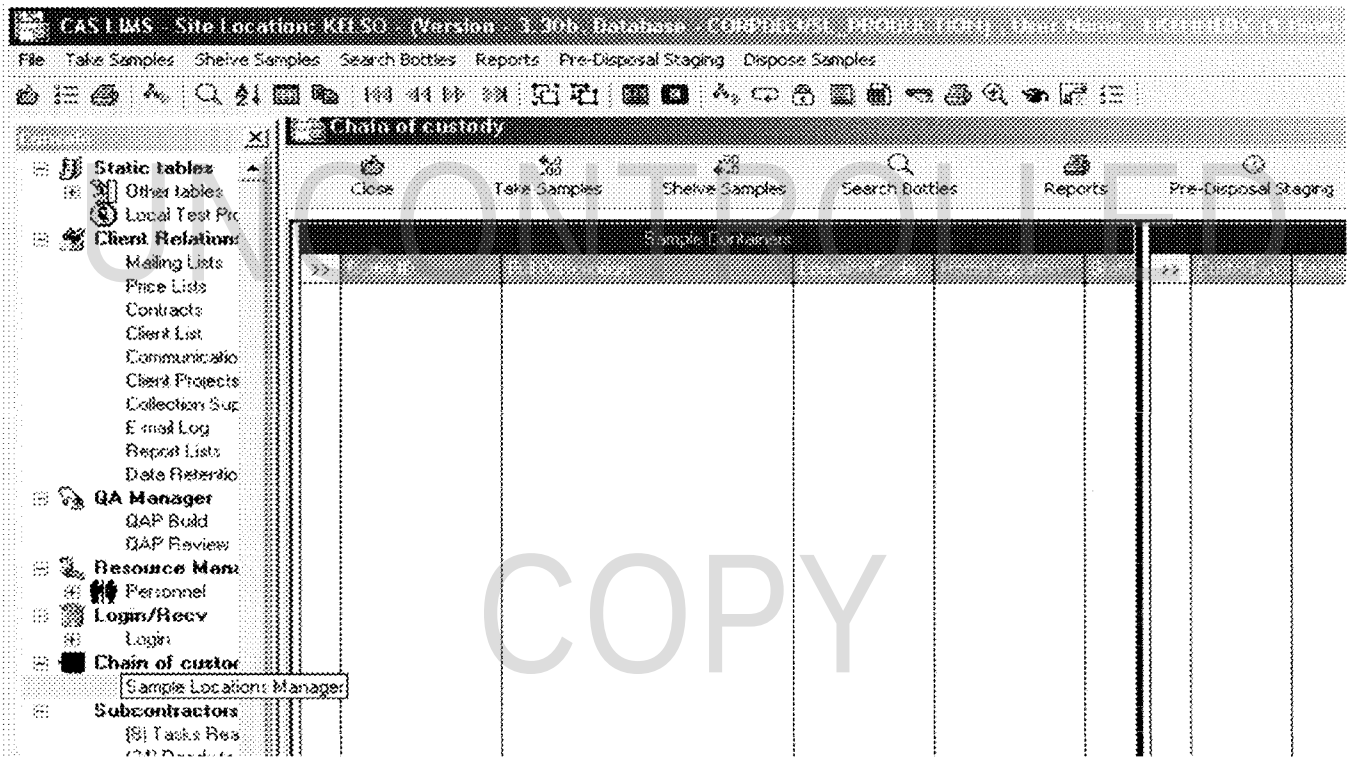
6.4.4. Using the barcode reader, read the barcode for each sample to be removed and taken into custody. The sample list will appear in the window displayed. It is recommended that a brief comparison of the displayed list and the actual container IDs be made.

6.5. Returning samples

6.5.1. When the analyst is finished working with the samples, the samples are returned to the main storage room and checked back in to complete the custody record. If the samples are returned during business hours or when a sample custodian is on duty, the sample can be left in the designated return area and SMO will scan and shelve the samples to the home location. If the samples are being returned after hours our outside the schedule of the sample custodians, the analyst must scan the samples to the appropriate designation "Cart in Delilah" or "Cart in Herk" etc. and place the samples, or sample cart, in the designated refrigerator(Sec 6.5.2). SMO will retrieve and scan them to their home location and shelve them the next business day. No samples other than room temperature samples can be left outside the refrigerator.

NOTE: Foreign soil samples or VOA samples must be scanned to their home location and placed in the proper refrigerator and shelf by the analysts or sample custodian. These samples must never be placed in a refrigerator outside of the one to which they are assigned.

6.5.2. To return samples after hours or outside SMO hours: Choose Sample Location Manager from the Chain of Custody tab and click the shelve samples button.



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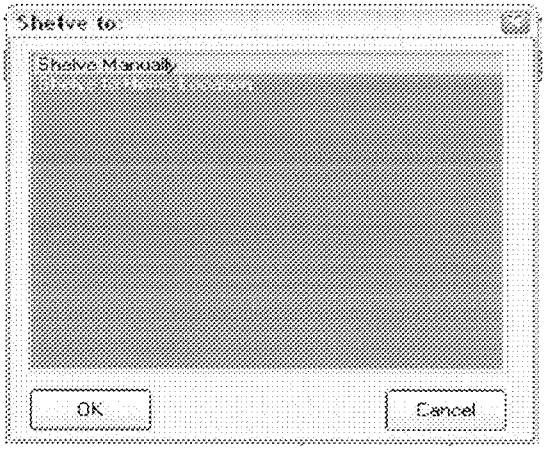
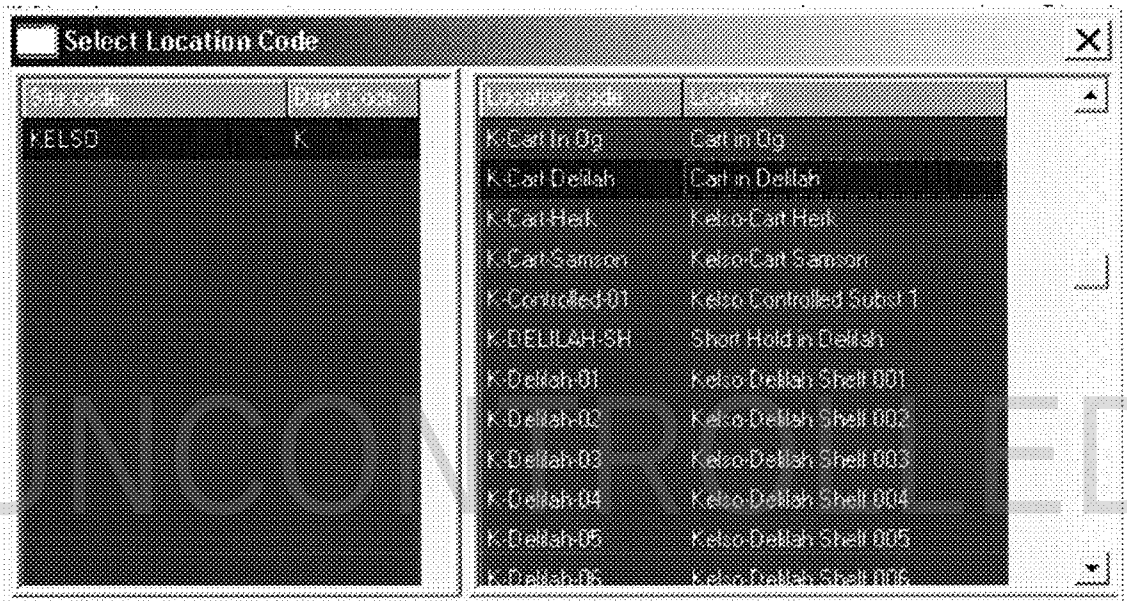
6.5.3. Choose "Shelve Manually" and click OK.



6.5.4. Choose the sample location (i.e. Cart in Delilah, Cart in Herk, etc.) by double clicking.



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6.5.5. Scan each sample container. DO NOT check the Empty checkbox even if the container is empty. Empty containers can be left on a cart outside the refrigerator and do not need to be scanned in.

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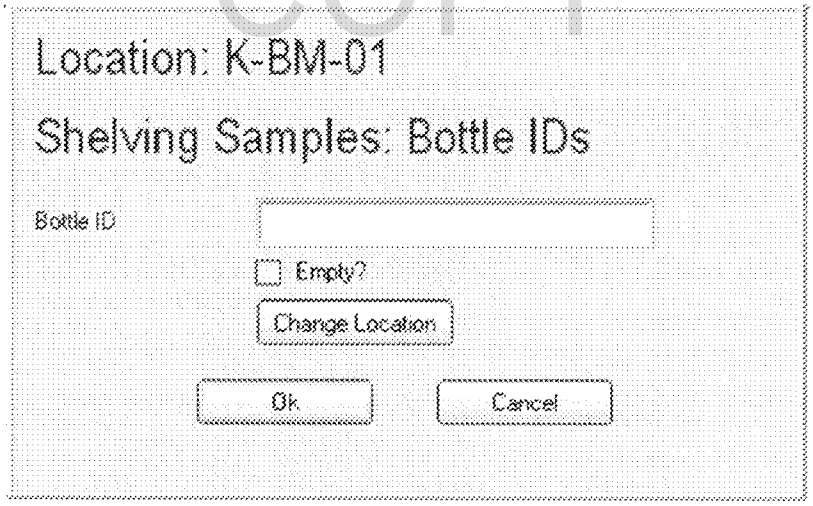

6.6. Sample tracking

6.6.1. Sample custody can be tracked via the Search function. Using this function, an analyst looking for a container that is in another analyst's custody can locate the container. The function is also used to document all custody events and provide internal chain of custody history. At the main menu window, choose Search Bottles. The Search window will appear.

6.6.2. The search can be done several ways by choosing one of the criteria in the Search Criteria window. The window will appear with all custody information.

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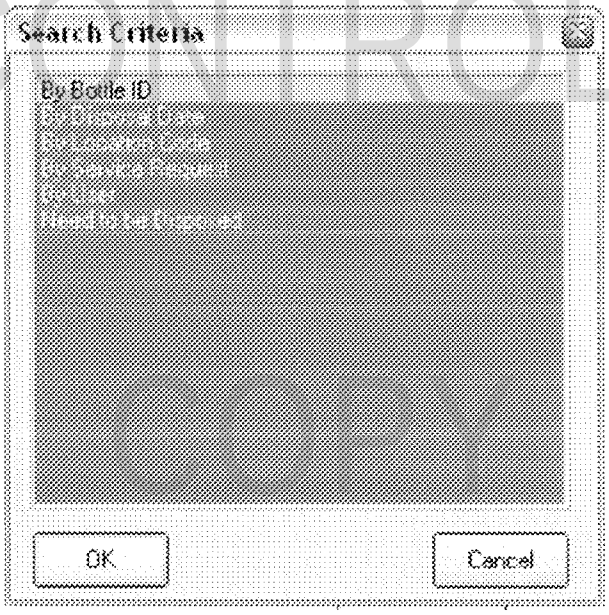


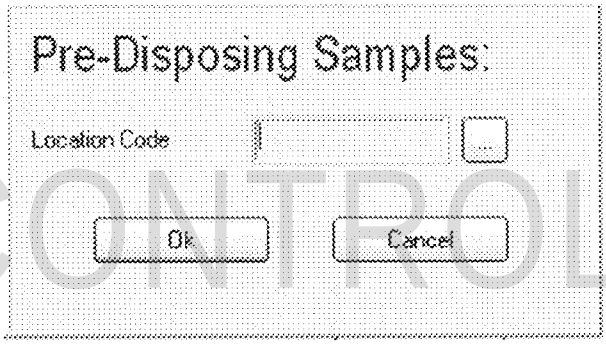
6.7. Custody of extracts and digestates

6.7.1. In labs where separate analysts prepare samples (extraction or digestion) for instrument analysis, the transfer of custody of completed extracts or digestates is documented. The instrument lab analyst accepts custody of the sample extract or digestate by signing on the benchsheet, or similar custody record, that they have accepted custody of those specific extracts or digestates listed. The date and time must accompany the signature.

6.7.2. For TCLP extracts, the finished extracts are labeled and logged into the LIMS system as a new container for the sample. The extracts are then stored as with other samples. Custody and tracking is then performed as for field samples as discussed in sections 6.1 and 6.2.

6.8. Pre-Disposal of Samples

6.8.1. When the analytical report has been shipped to the client, the sample containers are removed from refrigeration and placed on pre-disposal holding shelves while still in the custody of SMO. The shelves are referenced in order to facilitate retrieval of a sample if necessary. Transfer is documented using the Pre-Disposal and Location Selection windows.



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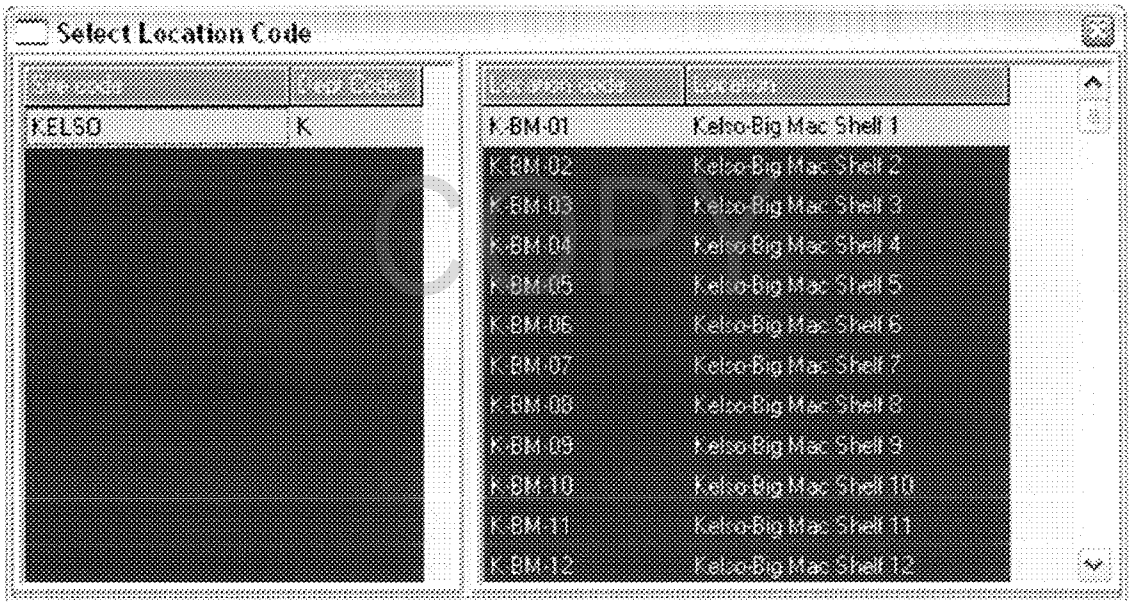

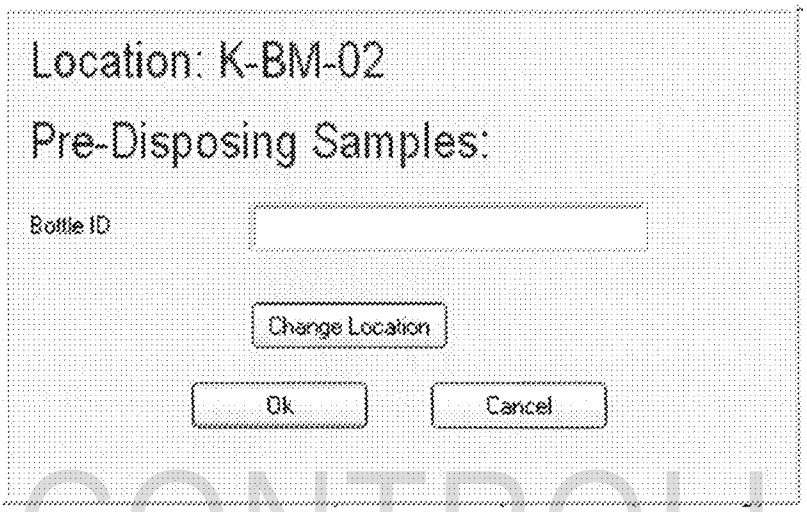

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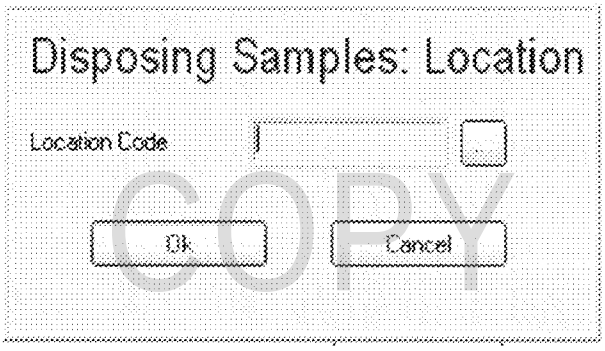
6.9. When sample disposal is performed, each container is scanned. Thus, the endpoint of CAS custody is documented by the final scan and documented disposal date (refer to the SOP SMO-SDIS *Sample Disposal*).



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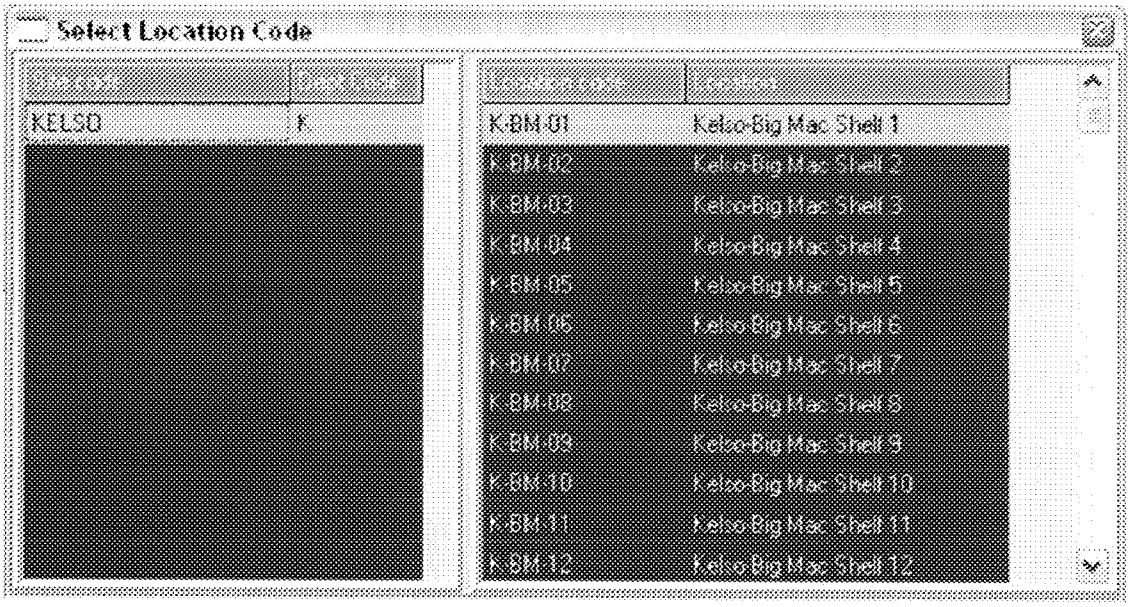

7. RECORDS AND REPORTS

7.1. Each service request will contain one or more references to the location of all of the associated sample containers. The record of hazardous/non-hazardous sample determination is kept in the original service request file.

7.2. After analyses are completed for the entire Service Request and the data is reported, the entire sample custody record is printed and placed in the original SR file. This, and other available reports, is found in the report selection window.

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7.3. Human resources and QA records are used to associate the analyst's initials to their actual handwritten signature. The database of internal custody records will be maintained for 5 years. Normal CAS procedures for electronic backup are used.

8. CHANGES SINCE THE LAST REVISION

8.1. Sec 4 Re-wrote to make more current.
8.2. Sec 5.1 Added sample custodian and analyst responsibilities.
8.3. Removed old section 6.1.3. Employee unique barcode ID.
8.4. Sec 6.1.1 Changed lims reference from Access to CAS LIMS
8.5. Sec 6.2 Added this section on how to request samples
8.6. Sec 6.3 How to fill a sample request
8.7. Sec 6.5 How to return samples

STANDARD OPERATING PROCEDURE

for

SAMPLE DISPOSAL

SOP No.: SMO-SDIS

Revision: 7

March 26, 2008

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Approved By: _____ Supervisor — 3/26/08 Date

_____ QA Manager — 3-26-08 Date

_____ Laboratory Manager — 3/26/08 Date

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Kelso, Washington 98626

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Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL

NUMBER: _____

Initials: _____ Date: _____

SAMPLE DISPOSAL

1. PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to describe procedures for the disposal of unused portions of samples. Based upon the results of the analyses performed by the laboratory and other knowledge supplied by the customer. A sample is categorized as non-hazardous or potentially hazardous and this SOP describes procedures for disposal of each type. This categorization assumes contaminates requested for analyses are the only hazardous substances contained in the sample.

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2. APPLICABILITY

The procedures for disposal described in this SOP applies to all sample types: aqueous, soil, solid, sediment, tissue, solvents, etc. The procedures for disposal described in this SOP also apply to all testing by-products.

3. DEFINITIONS

3.1. Sample: The material collected by a Customer in a container and delivered to the Laboratory for chemical analysis.

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3.2. Testing By-Product: The material produced in the course of a chemical analysis, such as aqueous waste containing potentially hazardous substances.

3.3. Service Request: The document created by the laboratory at the time a sample is received at the laboratory and logged into the Laboratory Information Management System (LIMS). This document contains the client information, the sample identification and the instructions for the chemical analysis of the sample.

3.4. Custody record - External or internal COC document that clearly defines and documents who is/was in possession of a sample at a given time.

3.5. Login - The SMO process of accepting the sample, inspecting, and entering the sample information into the laboratory LIMS system.

3.6. Sample custodian – The sample management office (SMO) is considered to be the sample custodian for any period of time from sample receipt to sample disposal that the sample is not internally signed into custody by analytical personnel.

3.7. Sample tracking - Identifying or reproducing the path of sample custody throughout the laboratory.

4. RESPONSIBILITIES

4.1. It is the responsibility of the person or persons designated to categorize the samples (non-hazardous, potentially hazardous, etc.) that the determination is based upon the best available information and that the decision is based upon that information. It is also imperative that the assessment is done correctly versus established criteria.

4.2. It is the responsibility of the Sample Management Technician and designated Sample Custodian doing the disposal to follow the procedures described in this SOP so that the laboratory waste is properly, safely and legally disposed of. The Sample Management Technician and designated Sample Custodian have the responsibility of disposing of samples in the appropriate manner, based primarily on the hazardous criteria provided on the Service Request. This person will contact the assigned Project Chemist or the Safety Officer to resolve any uncertainties with regard to disposal. When in doubt as to the hazardous nature of a sample, the sample will be disposed of as hazardous.

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5. PROCEDURES

5.1. Determination of sample composition

5.1.1. Service Request and Sample Receipt

A Service Request is created for each set of samples received at CAS. This Service Request describes the sample information, the work to be conducted and other pertinent information, including any special handling or hazardous disclosure information provided to us by the Customer. This Service Request also provides information to be filled out by a designated person or persons with respect to the hazardous nature of the samples.

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5.1.2. Review of Analytical Results and Sample Categorization

5.1.2.1. Upon completion of chemical analyses by the laboratory, a certified analytical report is prepared for the customer that summarizes the analytical results obtained by the laboratory. This certified analytical report is typed, reviewed by the chemist and signed by the Project Chemist. After signing, the report is ready for distribution and the Service Request file containing all pertinent information concerning the analysis (including raw data) is ready for archiving.

5.1.2.2. At this time, the designated person or persons will compare the sample results in the certified analytical report (along with all potential hazardous materials information supplied by the Customer) versus the list of analytes in the Potentially Hazardous Materials Criteria (see Attachment I).

5.1.2.3. The designated person will indicate on the "Shipping Log" all of the samples that contained any known hazards above the listed limits as well as the appropriate waste stream for disposal (i.e. RCRA or PCB).

5.1.2.4. The sample custodian designates in the LIMS system all samples that are deemed hazardous from the "Shipping Log". The samples are labeled in the LIMS system as PCB, RCRA, Caustic, Corrosive, Halogenated, Non-Halogenated, Heat Sterilization waste.

5.2. Sample disposal

5.2.1. Pre-Disposal Holding

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5.2.1.1. The sample management technician prints out a pre-disposal report from the LIMS system. From that list, all of the indicated service requests are printed. The technician determines the need for special sample archiving requirements by reviewing the information on the service requests and in the "special archiving" book.

5.2.1.2. The samples are pulled from the refrigerators and scanned into the LIMS system to assigned pre-disposal holding shelves. Aqueous samples are held for 31 days after the report has been mailed to the customer, and soils, sludge's, sediments, and solid samples are held for 60 days (unless special archiving arrangements have been made). Pre-disposal holding shelves are labeled with the report date and the date for disposal.

5.2.2. Sample Disposal

5.2.2.1. When samples are ready for disposal, the sample custodian removes the bottles from the pre-disposal shelves and places them on transport carts. Each sample container is scanned into the LIMS system as "properly disposed". The LIMS system indicates to the sample custodian the hazardous nature of the sample scanned. The waste stream is written with a sharpie on the cap or label of the bottle (i.e. PCB=P, RCRA=R, Caustic=C, Corrosive=Corr, Halogenated=Halo, Non-Halogenated=Non-Halo, Heat Sterilization =Auto, etc.). The sample is segregated in the appropriate satellite storage area. A maximum of 50 gallons can be accumulated in the satellite storage area before disposal into drums.

5.2.2.2. The completed Service Request Form, describing the hazardous nature of the samples is filed in the Sample Disposal notebooks.

5.2.3. Disposal of Non-Hazardous Samples

5.2.3.1. All non-hazardous, unpreserved, aqueous samples are flushed down the drain with large quantities of water. All preserved aqueous samples are neutralized via 25% NaOH or 10% HCL and then discharged down the drain with large quantities of water. A neutralization log is kept of all neutralized batches discharged to the sewer system.

5.2.3.2. Soil, sludge, sediment and solid samples that do not contain any known potentially hazardous chemicals can be discarded into the garbage bin for standard waste disposal. Alternatively, if requested by the Customer, the samples can be returned.

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5.2.3.3. Disposal of Foul Condensate Samples

5.2.3.3.1. When SMO receives a cooler containing samples of Foul Condensate, the sample vials will be marked with a green sharpie across the bar code label (generated by the laboratory). Other sample ID's to include would be S.S. Feed, Stripped Condensate, turpentine.

5.2.3.3.2. At the time of sample disposal, these samples will be separated into a waste stream designated for treatment of samples containing high concentrations organosulfides.

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NOTE: The following steps will take place in a fume hood.

5.2.3.3.3. A dilute bleach solution will be prepared in a 2-3 gallon plastic bucket. The samples are opened and emptied into the bucket.

5.2.3.3.4. The waste water can be disposed of down the drain with running water. The empty sample containers are disposed of inside a plastic garbage bag and put in the garbage for standard waste disposal.

5.2.4. Disposal of Potentially Hazardous Samples

5.2.4.1. If chemical analysis or Customer disclosure information indicates that potentially hazardous materials are present in the samples, the materials are separated into separate categories according to the types of hazardous waste – RCRA and PCB.

5.2.4.2. If samples are regular RCRA hazardous waste, these samples will be placed in a 55 gallon hazardous waste drum marked for RCRA waste. Alternatively, these samples can be returned to the Customer if requested.

5.2.4.3. All samples with PCB written on the lid will be placed in a drum marked PCB Waste Only or returned to the customer if requested.

5.2.4.4. All hazardous waste samples, whether they are RCRA or PCB waste must be emptied into the appropriate waste barrel.

5.2.5. Disposal of Other Sample Types

5.2.5.1. If a sample does not fall within the aqueous, soil/sludge or other categories described above, the Sample Management Technician will consult the assigned Project Chemist or the Safety Officer on proper method of disposal. These samples are to be disposed of following general waste disposal criteria and may be distinct from the sample disposal criteria described in this SOP.

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5.2.5.2. All oil samples that do not contain PCBs or whose concentration is below the regulated level are to be placed into the RCRA waste drum.

5.2.5.3. Solvent samples are to be segregated as chlorinated and non-chlorinated and discarded into the appropriate 55-gallon waste drum marked chlorinated or non-chlorinated solvent waste. The waste solvent drums are then disposed of via an approved waste handling company.

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5.2.5.4. Aqueous process chemical samples that are non-hazardous may be discarded down the drain in accordance with section 5.2.3.1. These chemicals may include soaps, defoamers, and other similar materials.

5.2.5.5. Dry chemical samples, such as sodium benzoate and other dry chemicals are to be retained as samples and/or returned to the Customer. These retained samples will then be "lab-packed" for disposal at a hazardous waste landfill.

5.2.6. Sample Container Disposal

5.2.6.1. Sample containers are not to have any identification on them that links or ties the container to CAS. Thus, containers provided to clients do not list the laboratory name. Clients should be encouraged not to list CAS or their name on the label.

5.2.6.2. For non-hazardous samples, the containers are dumped in the normal laboratory garbage containers. If the container does have laboratory identification on the label, either the container itself should be destroyed, or the label obliterated.

5.2.6.3. For hazardous waste samples, glass containers are included in the sample waste handling. Once emptied, plastic containers are dumped in the normal laboratory garbage containers. If the container does have laboratory identification on the label, either the container itself should be destroyed, or the label obliterated.

6. RECORDKEEPING

6.1. An internal chain of custody record of all sample disposal is recorded in the laboratory LIMS system.

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Disposal of Non-Hazardous, Acidic or Caustic Water Samples

Waste Stream: Non-hazardous water sample disposal to sewer.

Date	Operator	Volume Disposed (L)	Neutralization Treatment Required	Final pH
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	
			25% NaOH 10% HCL None	

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Attachment I

Hazardous Waste Criteria from CAS Environmental Health and Safety Manual

7.3 *Potentially Hazardous Materials Criteria*

Units:	WATER	1.0 ppb (ug/L) = 0.001 ppm (mg/L) = 1000 ppt (ng/L)
	SOIL	1 ppm (mg/Kg) = 1000 ppb (ug/Kg)
General Chemistry		
	pH	<2.5 = Acid waste
		>10 = Caustic waste
	Flashpoint	<140°F = Flammable
	Cyanide	Hazardous at any level = RCRA
	Reactive Sulfide	Hazardous at any level
	Formaldehyde	>100,000 ppb (ug/L) or 100 ppm (mg/L) = RCRA Water Drum
	TOX, EOX, AOX	>100 ppm (mg/Kg) = RCRA Soil Drum
		>100,000 ppb (ug/L) or 100 ppm (mg/L) = RCRA Water Drum
	Hexavalent Chromium	Hazardous at any level

Metals	SOIL Mg/Kg (ppm)	WATER ug/L (ppb)	WATER mg/L (ppm)	TCLP mg/L (ppm)
Arsenic	>100	> 5000	> 5	> 5
Barium	>2000	> 100000	> 100	> 100
Cadmium	>20	> 1000	> 1	> 1
Chromium	>100	> 5000	> 5	> 5
Lead	>100	> 5000	> 5	> 5
Mercury	>4	> 200	> 0.2	> 0.2
Selenium	>20	> 1000	> 1	> 1
Silver	>100	> 5000	> 5	> 5
Hexavalent Chromium	-	Hazardous at any level		-

Pesticides -

	SOIL Mg/Kg (ppm)	WATER ug/L (ppb)	WATER mg/L (ppm)	TCLP mg/L (ppm)
Chlordane		> 30	> 0.03	> 0.03
Endrin	> 0.4	> 20	> 0.02	> 0.02
Heptachlor		> 8	> 0.008	> 0.008
Heptachlor Epoxide		> 8	> 0.008	> 0.008
Methoxychlor				> 10
Lindane	> 0.8	> 400	> 0.4	> 0.4
Toxaphene	> 10	> 500	> 0.5	> 0.5

Herbicides

	SOIL Mg/Kg (ppm)	WATER ug/L (ppb)	WATER mg/L (ppm)	TCLP mg/L (ppm)
2,4 -D	> 200	> 10000	> 10	> 10
2,4,5-TP (Silvex)	> 20	> 1000	> 1.0	> 1.0

Semivolatile - 8270,

	SOIL Mg/Kg (ppm)	WATER ug/L (ppb)	WATER mg/L (ppm)	TCLP mg/L (ppm)
Hexachloroethane	> 60	> 3000	> 3	> 3
Nitrobenzene	> 40	> 2000	> 2	> 2
Hexachlorobutadiene	> 10	> 500	> 0.5	> 0.5
2,4 -Trichlorophenol	> 2.6	> 130	> 0.13	> 0.13
Hexachlorobenzene	> 2.6	> 130	> 0.13	> 0.13
2,4,6 -Trichlorophenol	> 40	> 200	> 2	> 2
2,4,5 -Triclorophenol	> 8000	> 400000	> 400	> 400
Pentachlorophenol	> 2000	> 100000	> 100	> 100
Pyridine	> 100	> 5000	> 5	> 5
Cresols (o,m,p, total)	> 4000	>200000	>200	>200

Total Halogens >100 ppm (mg/Kg) = RCRA Soil Drum

>100,000 ppb (ug/L) or 100 ppm (mg/L) = RCRA Water Drum

Total PAH >10,000,000 ppb (ug/L) or 10,000 ppm (mg/L) = RCRA Water Drum

PCBs

>2ppm < 50 ppm (mg/Kg or mg/L) or < 50000 ppb (ug/L) = RCRA PCB Drum

> 50 ppm (mg/Kg or mg/L) or > 50000 ppb (ug/L) = TOSCA PCB Drum

Dioxins

Hazardous at any concentration = RCRA PCB Drum

PHC

	SOIL Mg/Kg (ppm)	WATER ug/L (ppb)	WATER mg/L (ppm)	TCLP mg/L (ppm)
Diesel	> 100	> 100000	> 100	
Gasoline	> 100			
Methanol	> 100			
Oil & Grease	> 100			

Explosives

SOIL mg/Kg (ppm)	WATER ug/L (ppb)	WATER mg/L (ppm)	TCLP mg/L (ppm)
> 100	> 100000	> 100	

VOA

	SOIL mg/Kg (ppm)	WATER ug/L (ppb)	WATER mg/L (ppm)	TCLP mg/L (ppm)
Benzene	> 10	> 500	> 0.5	> 0.5
Carbon Tetrachloride	> 10	> 500	> 0.5	> 0.5
Chlorobenzene	> 2000	> 100000	> 100	> 100
Chlordane	> 0.6	> 30	>0.03	>0.03
Chloroform	> 120	> 6000	> 6.0	> 6.0
1,4 - Dichlorobenzene	> 150	> 7500	> 7.5	> 7.5
1,2 - Dichloroethane	> 10	> 500	> 0.5	> 0.5
1,1 - Dichloroethylene	> 14	> 700	> 0.7	> 0.7
2,4 - Dinitrotoluene	> 2.6	> 130	> 0.13	> 0.13
Hexachlorobenzene	> 2.6	> 130	>0.13	>0.13
Methyl Ethyl Ketone	> 4000	> 200000	> 200	> 200
Nitrobenzene	> 400	> 2000	> 2.0	> 2.0
Tetrachloroethylene	> 14	> 700	> 0.7	> 0.7
Trichloroethylene	> 10	> 500	> 0.5	> 0.5
Vinyl Chloride	> 4	> 200	> 0.2	> 0.2
BTEX	> 100	> 100000	> 100	>100
Benzene	> 10	> 20000	> 20	
Toluene	> 20	> 20000	> 20	
Ethylbenzene	> 20	> 20000	> 20	
Xylene	> 20	> 20000	> 20	
MTBE	> 100	> 100000	> 100	>100

- Based on Washington State Criteria

Table 7-2—Hazardous Materials Criteria

STANDARD OPERATING PROCEDURE

for

DATA ARCHIVING

SOP No.: ADM-ARCH

UNCONTROLLED

Revision 4

August 7, 2008

Approved by: _____ Client Services Manager — 8/8/08 Date

_____ QA Manager — 8-8-08 Date

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_____ Laboratory Director — 8/8/08 Date

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DATA ARCHIVING

1 SCOPE AND APPLICATION

1.1 This Standard Operating Procedure (SOP) describes a standard system for archiving laboratory data and associated records for Columbia Analytical Services' Kelso, Wa. facility. This procedure applies to laboratory data kept in service request (project) files and to data organized and bound by laboratory sections. The procedure also describes a system for retrieving archived data for later review or submittal to clients.

1.2 Backup and archiving of electronic data is not addressed in this procedure. Refer to the CAS Software Quality Assurance Plan and the *SOP for Tape Backup and Tape Archiving*.

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1.3 This SOP does not apply to EPA Contract Laboratory Program data archiving, which has distinct data archiving procedures defined in the Statement of Work for the contract. For those procedures, refer to the CLP category of SOPs.

2 SUMMARY OF SYSTEM

2.1 A defined system for archiving data is required in order to provide a permanent record of all analytical procedures used in a given sample analysis. Also, it is important to maintain a permanent record of the analytical report. Archived records must provide all information needed to reconstruct the entire laboratory process.

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2.2 It is laboratory policy to archive all sample handling records, analytical reports, raw data, and associated records applicable to all analyses performed. Certain records, such as project supporting documentation and laboratory logbooks, will be retained in hard copy form. Analytical reports may be retained in either hard copy or electronic (pdf) form. Laboratory records (typically raw data) associated with multiple service requests or projects is bound by the laboratory staff and submitted to the records staff. Service request files are routed to the records clerk as a function of the post-reporting system. The service request files will contain all project supporting documentation and (when hard copy) a copy of the analytical report and the sample raw data. Service request files are then archived in a sequential file system by service request number. This includes a set of files for short-term holding/staging and permanent long term storage.

2.3 The default data retention period to archived data is five (5) years from the completion of a project. However, binding contracts or project requirements, programs, or regulations may specify a shorter or longer period. For example, for projects originating in Alaska or Louisiana, the record retention time is 10 years. For those contracts with longer retention periods than the 5 year period, clients will be given the opportunity to take possession of their documents, or CAS will retain them for the required period.

2.4 Once the retention period has elapsed, documents associated with the "expired" projects will be destroyed. The lab will dispose of the data unless the client makes arrangements to take possession of it.

3 RESPONSIBILITIES

3.1 It is the responsibility of the laboratory staff submitting reports and supporting data to a service request file to provide all data directly related to an analysis. This is essential so that the analysis can be reconstructed from the archived data. When certain data pertains to multiple analyses (calibration, tuning, blank data, etc.) the lab must have systems in place to provide copies of this data or archive this data separately.

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3.2 Throughout the process of creating, assembling, copying, and mailing the analytical report, all staff involved (filing, report production, project chemist, copy center) are responsible for the service request file contents as a whole. Steps must be taken to ensure that all data required in the file is kept in the file.

3.3 It is the responsibility of the records staff to maintain the archiving system and to follow this procedure. Staff members must be properly trained on its use.

3.4 It is the responsibility of project chemists to inform the records staff of data retention requirements (timeframes, notifications, etc.) that differ from standard procedures.

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4 DEFINITIONS

Analytical report - The Certified Analytical Report generated by the laboratory, in final form as delivered to the client, in both hard copy and electronic formats.

LIMS - CAS Laboratory Information Management System

Raw data - Any hard copy laboratory data associated with a given analysis. May be archived with the service request file or separately.

Service Request File (SR) - This is the physical file which contains all documentation associated with a given set of samples (chain of custody, sample receipt information, etc.). The service request identifies the analyses and reporting to be done for the sample(s). The CAS LIMS assigns a unique number to each service request. Also known as report file or project file.

5 PROCEDURE

5.1 Data Retention Period

5.1.1 The standard data retention time for analytical reports, SR files and laboratory data records is 5 years unless otherwise noted in Tables 1 and 2. Changes to Tables 1 and 2 can be made on the SOP Change Form accompanying the distributed SOP, and are to be incorporated into future revisions of this SOP.

NOTE: Longer client or project record retention may supersede agency requirements.

5.1.2 Table 1 lists data retention rules for different state and federal programs. Records falling under these states or programs must be held for the time period listed before disposal.

5.1.3 Table 2 lists data retention rules for various clients and projects. Records for these must be held for the time period listed before disposal.

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5.1.4 Quality Assurance records (section 5.4) are held indefinitely.

5.2 Service Request Files

5.2.1 After the copy center has scanned and/or copied and shipped the analytical report, the SR file is forwarded to the clerk performing hazardous materials review. The LIMS provides a record of report shipment and completion

5.2.2 Following shipment and hazardous materials review, the SR file is forwarded to the records clerk. Out cards are provided for any files that may have been checked out during the process.

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5.2.3 The content of the data file is verified to ensure that all necessary records are included. The following contents (in general order) are accounted for:

- File tracking sheet(s)
- EDD sheet
- Hazardous review sheet
- Chain of custody (if not included in report)
- Report pages (when archived hard copy)
- Lab generated data (raw data), general chemistry followed by metals followed by organics.
- Miscellaneous sheets/documents (instructions, notes, phone logs, etc.)
- SR acknowledgment
- Internal COC.

5.2.4 Analytical reports archived electronically are kept in the R:\copy network directory. A tape backup is performed each day, and tapes are handled as described in the SOP for Electronic Data Backup and Archiving. As the directory fills, the electronic reports are moved to DVD and stored in a designated area.

5.2.5 Short term holding/staging

5.2.5.1 Report files are centrally located in the records room file cabinet bank. Large files (approximately 500 pages or more) are placed on shelves near the file bank.

5.2.5.2 To check out a file from this area, the file is replaced with an out card indicating the date, service request number, and name or person it is checked out to. If the file has been checked out prior to arriving in the records area, an out card is placed in the file hanger (in portable file) where file would be located.

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5.2.5.3 Short term report holding is typically for a period of 4-6 weeks, depending on the number and size of files.

5.2.6 Long term archiving

5.2.6.1 After the period of short term holdng (when the oldest dated file drawer in short term holding is full) the files are prepared for long term archiving. The SR files are archived in separate, secured off-site facilities within close proximity of the laboratory.

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5.2.6.2 Organize the files in cardboard file boxes, within original manila file folders or expandable file folders.

5.2.6.3 The SR files are placed in file boxes in approximate numerical order and the file boxes are numbered sequentially. A File Archive Record listing the box number, files in the box, and file size (for larger files) is maintained in a 3-ring binder Exceptions to the numerical order are necessary due to large file sizes. These exceptions are listed on the archive record sheet.

5.2.6.3.1If an out card is used, indicating that a file has been checked out, record this in the 3-ring binder. An out card is placed in the box in place of the file. The information recorded in the 3-ring binder includes when the file was checked out, client, who checked the file out, service request number, and project chemist's name. When the SR file is returned, the out card is removed.

5.2.6.3.2Write the year on the end of the file box along with the sequence of file numbers contained in file box. Boxes of files are transferred to the long-term storage facility All boxes are stored in numerical order.

5.2.6.4 The long term archiving storage is a controlled-access area. Records are protected from fire, theft, loss, environmental deterioration, and vermin. The area is locked at all times when not in use. An electronic access log is maintained for long term archiving storage. This is located on R:\Copy\Fileroom\Archived Files Access Log. Each time access is made to a storage area, the person accessing will complete the information on the form.

5.2.6.5 For retrieval of SR files, the checkout system is the same out card system as used with short term storage, with an out card left in the file box.

5.3 Laboratory Data Records

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5.3.1 Laboratory records (typically raw data) associated with multiple service requests or projects is bound by the laboratory staff and submitted to the records clerk. These data books are labeled according to instrument location and/or lab section.

5.3.2 Lab instrumentation books are transferred to the storage/archiving area. They are stored in file boxes, the boxes labeled and placed on labeled shelves. A record is kept to catalog the data books. The clerk maintains a hardcopy record and an electronic copy is kept.

5.3.3 The long term archiving storage is a controlled-access area off-site. Records are protected from fire, theft, loss, environmental deterioration, and vermin. The area is locked at all times when not in use.

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5.3.4 The check out system for the lab data books is the same as for file check out. The out card system is used by the records clerk. The out card will indicate who checked out the book, when the book was checked out and exactly which book was checked out. The out card is placed in the box or on the shelf in place of the book.

5.4 Quality Assurance Records

5.4.1 The QA staff periodically performs archiving of lab-wide quality assurance records. This includes certification records, controlled documents (historical SOPs, logbooks, etc.), training records, PT testing results, audit records, QAPPs, metrology records, etc. The QA staff places the records in sequentially numbered file boxes. An electronic record of the file box contents is maintained.

5.4.2 Archived QA records are stored in the long term data archiving storage units. Records are protected from fire, theft, loss, environmental deterioration, and vermin. The area is locked at all times when not in use.

5.5 Record Disposal

5.5.1 Following the data retention period (see section 5.1) data may be destroyed. In some cases, the client will require notification prior to disposal. In this case, document any cases where the records are to be held longer or provided to the client.

5.5.2 Records are disposed of by emptying file boxes and file folders into a dumpster. The files boxes, flex folders, file folders, etc are recycled for reuse.

5.6 Plan for Ownership Change or Laboratory Closure

5.6.1 In the event that laboratory ownership changes or the laboratory closes, it is expected that the disposition of laboratory records will be addressed in the legal documents associated with the change. The laboratory will notify clients of the change and will follow any instructions obtained from clients regarding archived records. This may include keeping the records in storage (transferring to the new ownership), transferring to the client, destroying them, or other options. Additionally, appropriate regulatory and state legal requirements concerning laboratory records must be followed.

5.6.2 If there is a change in ownership all records and analyses performed pertaining to NELAP and DoD accreditation/approval will be kept for a minimum of 5 years and will be made available for inspection by the accrediting authorities during this period.

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6 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

A review of the data archiving system will be included as part of internal auditing of data and reports conducted by quality assurance staff. Adherence to the procedures described in this SOP will be assessed. Any deficiencies uncovered will require corrective action as described in applicable audit reports.

7 RECORDS

Documentation and recordkeeping requirements are listed in Section 5.

8 REFERENCES

8.1 Quality Assurance Manual, Revision 17, Columbia Analytical Services, Inc., January 30, 2008

8.2 National Environmental Laboratory Accreditation Program (NELAP), 2003 Quality Standards.

8.3 Department of Defense Quality Systems Manual for Environmental Laboratories, Final Version 3, January 2006.

9 CHANGES FROM PREVIOUS REVISION

9.1 Section 2.2 revised.

9.2 New Section 5.2.4.

9.3 Section 5.2.5.4, added access log requirement and details.

9.4 Section 5.4.2, corrected QA storage area from upstairs corporate to off-site.

9.5 New Section 5.6

9.6 Section 6 revised to add current QA Manual, NELAP, and QSM references.

9.7 Minor formatting and typographical corrections.

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TABLE 1

Agency Record Retention Requirements

Federal/National Programs	Record Retention (yrs)	Comments
NFESC/Navy	10	Notify prior to disposal
U.S. Air Force (AFCEE)	5	
U.S. Army Corps of Engineers	5	
State Programs		
Alaska UST	10	
Arizona	5	DW*
Arkansas	(standard)	Record retention not found in certification rules
California	(standard)	Record retention not found in certification rules DW*
Colorado	5	DW*
Florida	5	DW*
Hawaii	10	DW*
Idaho	5	DW*
Indiana	5	DW*
Louisiana	10	DW*
Maine	(standard)	Record retention not found in certification rules DW*
Michigan	(standard)	Record retention not found in certification rules DW*
Minnesota	3 / 10	3 yrs for wastewater, 10 yrs for drinking water
Montana	5	DW*
Nevada	5	DW*
New Jersey	5 / 10	10yrs if lab is informed analyses are due to public health concerns
New Mexico	5	DW*
New York	6	
North Carolina	5	
Oklahoma	3 / 10	10 yrs for municipal water testing
Oregon	5	DW*
South Carolina	(standard)	Record retention not found in certification rules
Utah	5	DW*
Washington	(standard)	Record retention not found in certification rules DW*
Wisconsin	3	DW*
Wyoming (EPA Region8)	5	DW*

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* The EPA *Manual for the Certification of Laboratories Analyzing Drinking Water* states that "Public Water Systems are required to maintain records of chemical analyses of compliance samples for 10 years (40 CFR 141.33) and lead and copper for 12 years (40 CFR 141.91). The laboratory should maintain easily accessible records for five years or until the next certification data audit is complete, whichever is longer. The client water system should be notified before disposing of records so they may request copies if needed."

TABLE 2
Client/Project Record Retention Requirements

COMPNAME	Data Retention Years	Data Retention Notify
Camp Dresser & McKee, Incorporated (CDM)	5	Y
Hart Crowser, Incorporated	6	
Portland, City of	5	Y
Beazer East, Inc.	7	Y
URS Corporation	5	Y
Landau Associates,Inc.	6	
GeoTrans, Inc.	7	
ARCADIS of New York, Inc.	5	Y
Exponent	5	Y
Barr Engineering Company	5	Y
Bechtel Environmental, Incorporated	7	
Portland, Port of	5	Y
Brown and Caldwell	0	
Menzie-Cura Associates	5	Y
Cosmopolitan Engineering Group	5	Y
Tetra Tech EM, Incorporated	5	Y
Science Application International Corporation (SAIC)	5	Y
US Army Corps Of Engineers	5	Y
Metcalf & Eddy, Incorporated	10	
Environmental Quality Management	10	
Jacobs Engineering Group, Incorporated	10	Y
Integral Consulting, Incorporated	5	Y
Normandeau Associates	6	
SECOR International, Incorporated	7	
Malcolm Pirnie, Incorporated	10	
Environet, Incorporated	10	
Shaw Environmental & Infrastructure, Inc.	7	Y
TEC, Inc. - The Environmental Company,Inc.	10	
Montgomery Watson Americas, Incorporated	10	

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STANDARD OPERATING PROCEDURE

for

DATA REPORTING AND REPORT GENERATION

SOP No.: ADM-RG

Revision: 6

August 7, 2008

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Approved by: _____ Client Services Manager — 8/8/08 Date

_____ QA Manager — 8-8-08 Date

_____ Laboratory Manager — 8/8/08 Date

COLUMBIA ANALYTICAL SERVICES, INC.
1317 South 13th Avenue
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DATA REPORTING AND REPORT GENERATION

1. PURPOSE

This standard operating procedure (SOP) describes the procedures and guidelines used for reporting analytical results and generating analytical reports. General procedures applicable to all systems are described.

2. APPLICABILITY

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The procedures described in this SOP are applicable to the generation of all routine client-ready data reports. Where specified (e.g. AFCEE), project specific requirements take precedence over the SOP. The SOP is applicable to all analyses performed in the laboratory, with the exception of EPA CLP analyses and reporting. This SOP does not describe data review processes, which are given in the SOP for Laboratory Data Review Process.

3. DEFINITIONS

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3.1. Data Qualifier – The letter or symbol used to indicate an irregularity associated with the reported value. Also referred to as data flags. CAS employs the use of EPA CLP data qualifiers where applicable. Project-specific requirements may prescribe a certain list of allowable qualifiers.

3.2. MDL – Method Detection Limit. The MDL is the statistically determined minimum concentration of a substance or analyte that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix type containing the analyte.

3.3. MRL – Method Reporting Limit. The Method Reporting Limit is the routinely reported lower limit of quantitation to which CAS routinely reports results in order to minimize false positive or false negative results. The MRL is normally two to ten times the method detection limit. Some reporting specifications may require the use of equivalent nomenclature for the MRL, such as Estimated Quantitation Limit (EQL) and Practical Quantitation Limit (PQL), Reporting Limit (RL), etc. The reported MRL may be adjusted if required for specific project requirements; however, the capability of achieving other reported MRLs must be demonstrated.

3.4. Reporting systems – Purchased or in-house software used to generate reports. This includes Microsoft Excel and MARRS, as well as in-house developed Harold, Blackbird, and Stealth.

3.5. Tier level – Specifies the data deliverable level for the project (i.e. the amount of information provided in the analytical report package). Tier levels are typically specified by the customer and are indicated by the CAS numeric value for the tier (tier I, II, III, etc.)

4. DISCUSSION

The SOP is intended to provide procedures and guidelines for data reporting that lead to a final report that meets client expectations and project requirements. In some cases, it may be difficult to employ all of the rules incorporated in the SOP due to the nature of the project or samples involved. If circumstances arise which make implementation of the SOP impractical, the laboratory section and Project Chemist should determine the reporting procedure to be used.

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5. RESPONSIBILITIES

All staff members responsible for reporting data and generating reports are required to familiarize themselves with the SOP. It is the supervisor and/or department manager's responsibility to ensure adequate training is given to the appropriate staff. Training of all laboratory staff members, including those performing any level of data review, is required.

6. PROCEDURE

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6.1. Reporting Systems and Processes

6.1.1. Various reporting systems are used depending on the type of analysis (organic, inorganic, metals, etc.). The department manager oversees the implementation of reporting systems in the department. Persons generating reports should refer to operating instructions and/or training for details on generating reports.

6.1.2. Metals

6.1.2.1. The Harold reporting software is used when data is reported to the MRL only and when preparing tier I or tier II reports. The MARRS reporting system is used when data is reported to the MDL and when tier III; as well as when specialized EDDs are requested.

6.1.2.2. In general, the analysis data contained on bench sheets and in the raw instrument output is first reviewed for technical accuracy and completeness. The data is entered into the reporting system manually or by download from instrument files.

6.1.2.3. Based on the tier level and type of report specified, the person generating the reports selects the necessary report forms and content. The forms are generated electronically and printed as hard copy reports.

6.1.3. General Chemistry

6.1.3.1. The current system uses a sequential process with the final report generated using the Blackbird reporting software.

6.1.3.2. The analysis data contained on bench sheets and in the raw instrument output is entered onto Excel-based bench sheets in the LIMS. The bench sheets are then reviewed for technical accuracy and completeness.

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6.1.3.3. The Excel bench sheet is transferred through the LIMS to the Blackbird reporting system where final reports are generated based on the tier level and type of report specified. The person generating the reports selects the necessary report forms and content. The forms are generated electronically and printed as hard copy reports.

6.1.4. Organics

6.1.4.1. The Stealth reporting system is used as the default system.

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6.1.4.2. Reports are generated by compiling the SMO login, sample prep database, downloaded instrument data, and any client-specified requirements. This compilation is then transferred to a file which the Stealth reporting system uses to validate the data and generate a report. The forms generated may be CAS standard reports, DOD, or client-specific reports. The compiled data from LIMS is also used to create EDDs.

6.1.4.3. Excel may be used as an alternative system or for applications where Stealth is not yet developed. Reports are generated using Excel© templates located on the in R: drive. The analyst should choose the appropriate form and QC pages to correspond to required tier level and deliverables requirements. The person generating the report selects the necessary report forms and content (detected analytes, surrogate and matrix spikes, etc) and then transferred, by hand or electronically, to the templates.

6.2. General Data Results Reporting Guidelines and Standard Reporting Convention

6.2.1. Acronyms are commonly used throughout the analytical reports and referred to in the SOP. For a list of acronyms, refer to Appendix I.

6.2.2. Results are reported as either 1) A numerical value when detected at or above the MRL in the sample, 2) A numerical value footnoted as an estimated value when detected at or above the MDL but less than the MRL in the sample, or 3) Non-detect (ND or "MRL"U) when not detected in the sample at or above the MRL and results are not required to be reported below that level.

6.2.3. When preparing any data reports, it is essential that the reporting specifications be reviewed. The person preparing the data reports should determine what data is to be reported, the tier level, report format, and flagging conventions. The project-specific reporting information is found on the service request and the Tier V form.

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6.2.4. Decimal Places, Significant Figures, and Rounding - Refer to the CAS SOP for Significant Figures (ADM-SIG.FIG).

6.2.5. Date Convention

6.2.5.1. When all of a project's samples are collected on one day, received at the laboratory on one day, extracted on one day, and analyzed on one day, the reporting of these event dates is straight forward. The policy described here addresses the situation that arises when these events happen on multiple days.

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6.2.5.2. Date collected, received, extracted and analyzed

6.2.5.2.1. When standard CAS forms are used and the samples are collected, received, extracted and/or analyzed over several days, these dates are reported as a range. For example if samples were received 4/7, 4/9 and 4/19 the date received is reported as 4/7-19/00. If the range covers more than one month, report as 4/7-5/2/00.

6.2.5.2.2. When DOD reporting is used and there is one sample reported per page, only one date received and date collected is entered. When multiple samples are reported per page for DOD projects, a date range is used on the 1st page of the DOD form with the specific dates for each sample/analyte reported on page 2 of the DOD form. When samples are received over multiple days, the dates received are determined from either reviewing each service request or by printing the internal login summary from LIMS.

6.2.6. Naming Conventions

6.2.6.1. Project Name and Number

When the project name and number are transferred to the report form the following format will be followed:

Project Name/Project Number. i.e. Acme Landfill/4001-001.002

There is no space between the name, slash and the number. There is no "#" sign before the project number.

6.2.6.2. The entire sample ID, Project Name etc. must be entered onto the report exactly as it is on the service request. If it won't fit in the cell, use the "edit selection" and "paste changes" buttons on your toolbars to decrease the size of the font to 9. If it still doesn't fit, decrease to 8. Do not decrease the size of the font below 8. If it doesn't fit with 8, see the project chemist. When making font changes to the header information, change all three lines of the header so that the font sizes are the same.

6.2.6.3. To differentiate between an original analysis and a reanalysis when both are being reported, append an "RE" to the end of the lab code for the reanalysis (i.e. K2001469-001RE).

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6.3. Reporting Method Reporting Limits (MRLs) and Method Detection Limits (MDLs)

6.3.1. Routine MRL values to be used are listed on the standard forms. MRLs are elevated under one or more of the following circumstances:

NOTE: The objective of the following guidelines is to minimize the frequency of elevating the MRL.

- Low percent solids: Adequate sample should be prepared to avoid having to raise MRLs.

% Solids	Raise MRL by
>50	Do not raise MRL*
41-50	2X
11-40	5X
≤10	10X

- Limited sample amount: Raise MRLs due to limited sample amount only if the sample amount prepared is 50% or less of optimal amount*.

* provided the MRL is supported by the low calibration standard concentration.

- Dilutions: Raise MRLs according to the dilution factor.

- Matrix Interference: Raise MRLs if the sample matrix interfered with the detection of an analyte. Raise the MRL to the level of the interference.

6.3.1.1. Reporting elevated MRLs

6.3.1.1.1. Standard forms: When results are ND, enter the adjusted MRLs in the Results column. Precede the raised MRL with a "<". The values in the MRL column are not changed.

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6.3.1.1.2. DOD forms: Raise the MRLs in the MRL column for the analyte. Enter a dilution factor for any MRL or result adjusted due to a dilution. i.e. *initial MRL x dilution factor= final MRL*. If multiple dilutions are reported on the same page, the appropriately adjusted MRL and dilution factor should be listed for each analyte. NOTE: IF reporting an analyte, the MRL must be elevated by the dilution factor.

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6.3.2. When reporting to the MDL, results will be reported to the value identified as the reporting MDL. The reporting MDL is the statistical MDL rounded up to the applicable number of significant figures; and when multiple instruments are used is the highest MDL from multiple instruments. The following rules apply when reporting results to the MDL:

6.3.2.1. Do not report below the MDL.

6.3.2.2. Clear any "MDL" heading and MDL values from the report form.

6.3.2.3. MDLs are elevated following the same procedure used for MRLs (above) and by the same factor determined for the MRL. It is recognized that an *elevated* MDL does not represent the experimentally determined value, however, it represents a more technically sound "limit of detection" for the particular sample. The project Case Narrative must discuss the elevated MDL and convey that the reported MDL does not represent the experimentally determined value applicable to that sample or analyte.

6.3.3. Elevated MRLs and MDLs should be footnoted as follows:

6.3.3.1. If all of the MRLs/MDLs pertaining to one sample are raised by the same factor, flag on the report as follows:

6.3.3.1.1.Standard forms: The footnote is attached to the sample laboratory code without a space and in parentheses, i.e. K0809999-001(C).

6.3.3.1.2.DOD forms: The qualifier is added to the "test notes".

6.3.3.2.If the raised MRL/MDL pertains to one analyte:

6.3.3.2.1.Standard Forms: the footnote is attached to the result in parenthesis, to the right of the number with no space. i.e.: 16 (C)

6.3.3.2.2.For DOD Forms: the footnote is entered in the Result Note column with NO parenthesis.

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6.4. Reporting QC Data

6.4.1. Naming Duplicate, Matrix Spikes and Duplicate Matrix Spikes

When reporting duplicates, matrix spikes and duplicate matrix spikes, the appropriate abbreviation must be appended to the lab code. Examples:

K0809999-001D (for the duplicate analysis)
K0809999-001MS (for the matrix spike analysis)
K0809999-001MS, K0809999-001DMS (for the MS/DMS analysis)

6.4.2. MS/DMS and LCS Results and Percent Recovery

6.4.2.1.On Matrix Spike and/or Duplicate Matrix Spike and Laboratory Control Sample Summary QA/QC Report Pages:

6.4.2.1.1.The Spike level is the known concentration of the analyte added to the sample. Report the spike level on matrix-spiked samples and the true value on laboratory control samples to two significant figures. Report the spike level on matrix-spiked soil samples based on the (actual) sample weight - either dry weight or as received, as appropriate.

6.4.2.1.2.The sample result is the same result that is reported for that analyte on the sample result page.

6.4.2.1.3.The spike result is the spiked analyte result as determined by the analysis. Matrix spike results are reported regardless of analyte

concentration in the parent sample. In cases where the spiked analyte concentration exceeds the calibration range due to high analyte concentration in the parent sample, the spike result is reported as the measured amount and an "E" flag is put in the appropriate result note field. The E flag is explained in the case narrative.

6.4.2.1.4.The sample and spike results are calculated and rounded to the appropriate number of significant figures. Those results are then used to calculate the percent recovery. Percent recovery for MS/DMS is always calculated and reported. Percent recoveries that calculate as negative values are reported as negative recoveries and flagged appropriately and explained. If the spike amount is less than 25% of the parent sample concentration, the appropriate case narrative macro is NAMS2 and the result reported.

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6.4.2.2.Report percent recoveries rounded to the nearest whole number.

6.4.2.2.1.If the % Recovery is <10%, report the % Recovery with **one** significant figure

6.4.2.2.2.If the % Recovery is <100%, report the % Recovery with **two** significant figures

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6.4.2.2.3.If the % Recovery is >100%, report the % Recovery with **three** significant figures

6.4.2.2.4.If the percent recovery is outside of acceptance limits because of rounding, up to three significant figures can be used.

6.4.3. Reporting RPDs

6.4.3.1.For matrix spike and sample duplicates the unrounded spike or sample results are used to calculate the RPD. Since RPD is calculated from the measured concentration and not the percent recovery, there should always be an RPD value reported. This provides the client with a measure of precision.

6.4.3.2.For sample duplicates, if both the sample result and the duplicate sample result are ND, report the average as ND and the RPD with one dash "-".

6.4.3.3. For sample duplicates, if either the sample result or the duplicate sample result is ND and the other result is a reportable value, the average is reported as NC and the RPD is reported as NC. The NC is not footnoted. It is on the acronym page of the final report.

6.4.4. Surrogate Reporting – Organics Analyses

6.4.4.1. Percent recovery is always calculated and reported. A numeric recovery value is reported (NA, NC, <1, and "-" are not valid recoveries). Recoveries are rounded to the nearest integer and reported as positive integers or zero.

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6.4.4.2. If the sample has been diluted, the dilution factor is applied to the solution concentration prior to calculating recovery. If the surrogate analyte has been diluted to a level that is below the instrument detection limit, the reported recovery is zero. The recovery is flagged as being outside control criteria and explained in the case narrative.

6.4.4.3. If the surrogate recovery shows a positive bias due to matrix interference, flag the recovery as being outside control criteria and explain in the case narrative (as matrix interference).

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6.4.4.4. If the surrogate was not added to the sample due to lab error and the sample analysis is reported, the reported recovery is zero. Flag the recovery as being outside control criteria and explain in the case narrative.

6.4.5. Method Blank Contamination

6.4.5.1. The analyte concentration in the sample is not to be corrected for the method blank concentration except as specified in the SOP for the analysis.

6.4.5.2. An MRL is <u>not</u> to be increased when the analyte was found in the method blank above the MRL. Ideally, in such cases the method blank and associated samples should be reprepared and reanalyzed; however, constraints such as holding time or sample quantity may preclude reanalysis. The project chemist must be consulted prior to determining if it is necessary to reanalyze a sample past the recommended holding time.

6.4.5.3. When reanalysis is not practical or possible, the method blank result(s) will be reported as described below. See Table 1 for additional clarification.

6.4.5.4. Twenty Times Rule

6.4.5.4.1. If the concentration in the associated sample is ND, the result for the sample is reported as ND and without a footnote.

6.4.5.4.2. If the concentration in the associated sample is greater than the MRL but less than twenty times the method blank concentration, the result for the sample is flagged appropriately.

6.4.5.4.3. When the associated method blank has an analyte concentration below the MRL and the concentration in the associated sample is greater than the MRL but less than twenty times the method blank concentration, the laboratory narrative will address the possibility of lab contamination as appropriate.

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6.4.5.4.4. When reporting to the MDL, if the analyte concentration in the associated sample is less than the MRL, the sample result is flagged with a "J". The laboratory narrative will address any situations where there is a possibility of lab contamination.

6.4.5.4.5. If the concentration in the associated sample is greater than twenty times the method blank concentration, where the method blank concentration is above the MRL, the result for the sample is reported following CAS reporting policy and without a footnote.

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6.4.6. Reporting Batch QC

For QA/QC samples that are performed as batch QC from a different service request, the sample ID on the report will read "Batch QC" (using the exact upper and lower case as specified). The dates collected and received for batch QC should be NA.

6.4.7. Results Not Reported

For results that you do not want reported, an "NR" must be appended to the tab in the Excel electronic file. DO NOT "NR" the MS or LCS when MS/MSD or LCS/LCSD are reported.

6.5. Data qualifiers

6.5.1. A list of standard CAS data qualifiers, or flags, is given in Appendix II. Project specifications may require different or additional flagging conventions. Additional state-specific flagging instructions (such as Arizona DHS) are included in Attachment A.

6.5.2. To the extent possible, samples are only reported if all QC measures are acceptable. If a QC measure is outside control criteria and the data is to be reported, all samples associated with the failed QC measure are qualified with the appropriate data qualifier.

When samples are analyzed that do not meet the sample acceptance criteria, the data will be qualified and an explanation will be provided in the Case Narrative. The Case Narrative will explain the acceptance criteria that were not met and the corrective action taken.

6.5.3. Placement of qualifiers

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6.5.3.1. Standard forms-qualifiers are placed in parentheses immediately after the value, no spaces. If multiple qualifiers are used they are separated by a comma and are in alphabetical order. The "J" qualifier does not go in parentheses, it follows immediately after the result, no space.

6.5.3.2. DOD forms-The qualifier goes in the appropriate "test note" or "result note" field. No parentheses are needed. If multiple qualifiers are used, separate them using a comma.

6.6. Data deliverables

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6.6.1. Once the data reports are complete, the data package is prepared. The analytical report pages, QC reports, raw data, and other report pages or data is summarized and compiled according to the tier level requested. The CAS tier levels and associated deliverable items included are listed in Appendix III.

7. CHANGES FROM PREVIOUS REVISION

7.1. Dropped "Excel" from title and applicability. Dropped 'Excel Forms' and 'DOD Excel Forms' in several sections.

7.2. Sections 3.4 and 6.1, added various reporting systems currently used.

TABLE 1

RULES FOR REPORTING WHEN THE TARGET ANALYTE IS PRESENT IN THE METHOD BLANK

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IF REPORTING TO THE MDL			
METHOD BLANK		**SAMPLE**	
If Result	*Report*	*If Result*	*Report*
<MRL	"J" Flag	<MRL	"J" Flag
		>MRL	No flag. Narrative comment if appropriate.
>MRL	No Flag	<MRL	"J" Flag
>MRL	No Flag	>MRL	Flag if <20X Method Blank

IF REPORTING TO THE MRL			
METHOD BLANK		**SAMPLE**	
If Result	*Report*	*If Result*	*Report*
<MRL	ND No Flag	>MRL	No flag. Narrative comment if appropriate.
>MRL	No Flag	>MRL	Flag if <20X Method Blank

Appendix I

CAS Reporting Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

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Appendix II
Standard CAS Data Qualifiers

Inorganic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
U	The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
i	The MRL/MDL has been elevated due to a matrix interference.
X	See case narrative.

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Metals Data Qualifiers

#	The control limit criteria is not applicable. See case narrative.
B	The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
E	The reported value is estimated because of the presence of matrix interference.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The reported value was determined by the Method of Standard Additions (MSA).
U	The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL has been elevated due to a matrix interference.
X	See case narrative.
*	The duplicate analysis not within control limits. See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.

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Appendix II
(continued)

Organic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
A	A tentatively identified compound, a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results (25% for CLP Pesticides).
U	The compound was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
i	The MRL/MDL has been elevated due to a matrix interference.
X	See case narrative.

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Additional Petroleum Hydrocarbon Specific Qualifiers

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

Appendix III
CAS Kelso Tier Levels and Associated Deliverable Items

Deliverable	Tier I	Tier II	Tier IIA	Tier III	Tier IV	Tier V
Cover Letter	R	R	R	R	R	R
Case Narrative	O	O	O	R	R	O
Sample Results	R	R	R	R	R	R
Method Blank Results	R	R	R	R	R	R
Surrogate Recovery	R	R	R	R	R	R
Chain of Custody	R	R	R	R	R	R
Cooler Receipt	O	O	O	R	R	O
Duplicate (inorganics, some fuels and metals)	NA	R	R	R	R	O
Matrix Spike/Duplicate Matrix Spike (organics)	NA	R	R	R	R	O
LCS	NA	NA	R	R	R	O
ICB/CCB	NA	NA	NA	R	R	O
ICV/CCV	NA	NA	NA	R	R	O
MB Summary (organics)	NA	NA	NA	R	R	O
LCS Summary (organics)	NA	NA	NA	R	NA	O
Tune Summary (GC-MS)	NA	NA	NA	R	R	O
Calibration Summary	NA	NA	NA	R	R	O
Run Log	NA	NA	NA	R	R	O
Prep. Log	NA	NA	NA	R	NA	O
Sample Cross-Reference	NA	NA	NA	R	NA	O
Internal Std. Summary	NA	NA	NA	R	R	O
Raw Data	NA	NA	NA	R	R	O
Confirmation Summary	NA	NA	NA	R	R	O
Florisil Cleanup (CLP Pest.only)	NA	NA	NA	NA	R	O
GPC (CLP Pest.only)	NA	NA	NA	NA	R	O
CLP Reporting Rules	NA	NA	NA	O	R	O
Form I for QC (organics)	NA	NA	NA	O	R	O
QAPP Specific Forms (i.e. AFCEE)	NA	NA	NA	NA	NA	O
Unmerged Reports	NA	NA	NA	O	R	O

R = Required

O = Optional (as specified in project specifications)

NA = Not Applicable

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Attachment A

State-specific Data Flagging Requirements

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Arizona Data Qualifiers
Revision 3.0
9/20/2007

Developed by the Sub-committee of the Arizona Environmental Laboratory Advisory Committee

This is an updated list of the Rev. 2.0 Arizona Data Qualifiers dated 11/26/2003, with some new qualifiers added, some obsolete ones deleted and some modified.

Using the following Arizona Data Qualifiers does not automatically denote acceptability to the Regulatory Agency. Arizona Department of Environmental Quality expects that data reported utilizing the following qualifiers, unless stated otherwise, is useable, scientifically valid and defensible. In the laboratory's judgment if the data should not be used for compliance, the T6 qualifier must be used. Other general guidelines for use and application of the following data qualifiers can be found as an attachment to this document (ATTACHMENT A).

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Note: For drinking water samples, please use the AZ Drinking Water Data Qualifiers 10/23/2001 [PDF 23K]

Microbiology:

A1 = Too numerous to count.
A2 = Sample incubation period exceeded method requirement.
A3 = Sample incubation period was shorter than method requirement.
A4 = Target organism detected in associated method blank.
A5 = Incubator/water bath temperature was outside method requirements.
A6 = Target organism not detected in associated positive control.
A7 = Micro sample received without adequate headspace.
A8 = Plate count was outside the method's reporting range. Reported value is estimated.

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Method/calibration blank:

B1 = Target analyte detected in method blank at or above the method reporting limit.
B2 = Non-target analyte detected in method blank and sample, producing interference.
B3 = Target analyte detected in calibration blank at or above the method reporting limit.
B4 = Target analyte detected in blank at or above method acceptance criteria.
B5 = Target analyte detected in method blank at or above the method reporting limit, but below trigger level or MCL.
B6 = Target analyte detected in calibration blank at or above the method reporting limit, but below trigger level or MCL.
B7 = Target analyte detected in method blank at or above method reporting limit.

Concentration found in the sample was 10 times above the concentration found in the method blank.

Confirmation:

C1 = Confirmatory analysis not performed as required by the method.
C2 = deleted
C3 = Qualitative confirmation performed.
C4 = Confirmatory analysis was past holding time.
C5 = Confirmatory analysis was past holding time. Original result not confirmed.
C6 = deleted
C7 = deleted
C8 = Sample RPD between the primary and confirmatory analysis exceeded 40%. Per EPA Method 8000C, the lower value was reported as there was no evidence of chromatographic problems.

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Dilution:

D1 = Sample required dilution due to matrix.
D2 = Sample required dilution due to high concentration of target analyte.
D3 = deleted.
D4 = Minimum Reporting Limit (MRL) adjusted to reflect sample amount received and analyzed.
D5 = Minimum Reporting Limit (MRL) adjusted due to sample dilution; analyte was non-detect in the sample.
D6 = Minimum Reporting Limit (MRL) adjusted due to an automatic 10X dilution performed on this sample for the purpose of reporting traditional drinking water analytes for wastewater requirements.

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Estimated concentration:

E1 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not possible due to insufficient sample.
E2 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to sample matrix.
E3 = Concentration estimated. Analyte exceeded calibration range. Reanalysis not performed due to holding time requirements.
E4 = Concentration estimated. Analyte was detected below laboratory minimum reporting limit (MRL).
E5 = Concentration estimated. Analyte was detected below laboratory minimum reporting limit (MRL), but not confirmed by alternate analysis.
E6 = Concentration estimated. Internal standard recoveries did not meet method acceptance criteria.
E7 = Concentration estimated. Internal standard recoveries did not meet laboratory acceptance criteria.

E8 = Analyte reported to MDL per project specification. Target analyte was not detected in the sample.

Hold time:

H1 = Sample analysis performed past holding time.
H2 = Initial analysis within holding time. Reanalysis for the required dilution was past holding time.
H3 = Sample was received and analyzed past holding time.
H4 = Sample was extracted past required extraction holding time, but analyzed within analysis holding time.
H5 = This test is specified to be performed in the field within 15 minutes of sampling; sample was received and analyzed past the regulatory holding time.

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BOD/CBOD:

K1 = The sample dilutions set-up for the BOD/CBOD analysis did not meet the oxygen depletion criteria of at least 2 mg/L. Any reported result is an estimated value.
K2 = The sample dilutions set up for the BOD/CBOD analysis did not meet the criteria of a residual dissolved oxygen of at least 1 mg/L. Any reported result is an estimated value.
K3 = deleted.
K4 = deleted.
K5 = The dilution water D.O. depletion was > 0.2 mg/L.
K6 = Glucose/glutamic acid BOD/CBOD was below method acceptance criteria.
K7 = A discrepancy between the BOD and COD results has been verified by reanalysis of the sample for COD.
K8 = Glucose/glutamic acid BOD/CBOD was above method acceptance levels.

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Laboratory fortified blank/blank spike:

L1 = The associated blank spike recovery was above laboratory acceptance limits
L2 = The associated blank spike recovery was below laboratory acceptance limits.
L3 = The associated blank spike recovery was above method acceptance limits.
L4 = The associated blank spike recovery was below method acceptance limits.

Matrix spike:

M1 = Matrix spike recovery was high; the associated blank spike recovery was acceptable.
M2 = Matrix spike recovery was low; the associated blank spike recovery was acceptable.
M3 = The spike recovery value is unusable since the analyte concentration in the sample is disproportionate to the spike level. The associated blank spike recovery was acceptable.

M4 = The analysis of the spiked sample required a dilution such that the spike recovery calculation does not provide useful information. The associated blank spike recovery was acceptable.
M5 = Analyte concentration was determined by the method of standard addition (MSA).
M6 = Matrix spike recovery was high. Data reported per ADEQ policy 0154.000.
M7 = Matrix spike recovery was low. Data reported per ADEQ policy 0154.000.

General:

N1 = See case narrative.
N2 = See corrective action report.
N3 = deleted.
N4 = The Minimum Reporting Limit (MRL) verification check did not meet the laboratory acceptance limit.
N5 = The Minimum Reporting Limit (MRL) verification check did not meet the method acceptance limit.
N6 = Data suspect due to quality control failure, reported per data user's request.

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Sample quality:

Q1 = Sample integrity was not maintained. See case narrative.
Q2 = Sample received with head space.
Q3 = Sample received with improper chemical preservation.
Q4 = Sample received and analyzed without chemical preservation.
Q5 = Sample received with inadequate chemical preservation, but preserved by the laboratory.
Q6 = Sample was received above recommended temperature.
Q7 = Sample inadequately dechlorinated.
Q8 = Insufficient sample received to meet method QC requirements. Batch QC requirements satisfy ADEQ policies 0154.000 and 0155.000.
Q9 = Insufficient sample received to meet method QC requirements.
Q10 = Sample received in inappropriate sample container.
Q11 = Sample is heterogeneous. Sample homogeneity could not be readily achieved using routine laboratory practices.

Duplicates:

R1 = RPD/RSD exceeded the method acceptance limit.
R2 = RPD/RSD exceeded the laboratory acceptance limit.
R3 = deleted.
R4 = MS/MSD RPD exceeded the method acceptance limit. Recovery met acceptance criteria.
R5 = MS/MSD RPD exceeded the laboratory acceptance limit. Recovery met acceptance criteria.

R6 = LFB/LFBD RPD exceeded the method acceptance limit. Recovery met acceptance criteria.
R7 = LFB/LFBD RPD exceeded the laboratory acceptance limit. Recovery met acceptance criteria.
R8 = Sample RPD exceeded the method acceptance limit.
R9 = Sample RPD exceeded the laboratory acceptance limit.
R10 = deleted.
R11 = The RPD calculation for MS/MSD does not provide useful information due to the varying sample weights when Encore samplers/methanol field preserved samples are used.

Surrogate:

S1 = Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits.
S2 = deleted.
S3 = Surrogate recovery was above laboratory acceptance limits, but within method acceptance limits. No target analytes were detected in the sample.
S4 = Surrogate recovery was above laboratory and method acceptance limits. No target analytes were detected in the sample.
S5 = Surrogate recovery was below laboratory acceptance limits, but within method acceptance limits.
S6 = Surrogate recovery was below laboratory and method acceptance limits. Reextraction and/or reanalysis confirms low recovery caused by matrix effect.
S7 = Surrogate recovery was below laboratory and method acceptance limits. Unable to confirm matrix effect.
S8 = The analysis of the sample required a dilution such that the surrogate recovery calculation does not provide useful information. The associated blank spike recovery was acceptable.
S9 = deleted.
S10 = Surrogate recovery was above laboratory and method acceptance limits. See case narrative.
S11 = Surrogate recovery was high. Data reported per ADEQ policy 0154.000.
S12 = Surrogate recovery was low. Data reported per ADEQ policy 0154.000.

Method/analyte discrepancies:

T1 = Method approved by EPA, but not yet licensed by ADHS.
T2 = Cited ADHS licensed method does not contain this analyte as part of method compound list.
T3 = Method not promulgated either by EPA or ADHS.
T4 = Tentatively identified compound. Concentration is estimated and based on the closest internal standard.
T5 = Laboratory not licensed for this parameter.
T6 = The reported result cannot be used for compliance purposes.

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T7 = Incubator/Oven temperatures were not monitored as required during all days of use.

Calibration verification:

V1 = CCV recovery was above method acceptance limits. This target analyte was not detected in the sample.
V2 = CCV recovery was above method acceptance limits. This target analyte was detected in the sample. The sample could not be reanalyzed due to insufficient sample.
V3 = CCV recovery was above method acceptance limits. This target analyte was detected in the sample, but the sample was not reanalyzed. See case narrative.
V4 = deleted.
V5 = CCV recovery after a group of samples was above acceptance limits. This target analyte was not detected in the sample; acceptable per EPA Method 8000C.
V6 = Data reported from one-point calibration criteria per ADEQ policy 0155.000.
V7 = deleted.
V8 = deleted.
V9 = CCV recovery was below method acceptance limits.

Calibration:

W1= deleted.

W2= deleted.

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ATTACHMENT A

"Guidance on the Usage of Data Qualifiers"

These standardized data qualifiers are for use in qualifying analytical results for compliance samples in Arizona to represent events that occurred during analysis. The technical subcommittee has endeavored to develop qualifiers that are succinct and narrow in scope to eliminate broad or multiple interpretations when assessing the impact on data. It must also be noted that due to the specialized nature of the individual qualifiers, it is likely that more than one qualifier may be needed in order to accurately represent the data.

Note:
1. Using the Arizona Data Qualifiers does not automatically denote acceptability to the Regulatory Agency.
2. As specified in the Arizona Adopted Rules, R9-14-615.C.9, *for each parameter tested at the laboratory for which quality control acceptance criteria are not specified in the approved method or by EPA or ADEQ,:*
   a. Use default limits provided in Exhibit II; or
   b. Statistically develop limits from historical data

   The laboratory has an option of using ADHS Default Limits which can be accessed at http://www.azdhs.gov/lab/license/tech/altdefaultlimit.pdf

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Microbiology:

None.

Method/calibration blank:

Apply appropriate qualifier to affected analyte in the blank if target analyte is not detected at ≥ RL in the samples. If analytes are detected, then all corresponding analytes for the associated samples should also be qualified.

Confirmation:

For methods that require qualitative confirmation. C3 applies to methods that require quantitative confirmation.

Dilution:

If all analytes are reported from the diluted sample, apply qualifier to the entire sample. Otherwise apply qualifier to each analyte that required dilution.

Estimated concentration:

Appropriate qualifier must be used for any analyte result reported outside the calibration range. Affects data reported outside the calibration range or down to the MDL. E8 is only required if additional clarification is necessary.

Hold time:

Qualify samples appropriately when method extraction and/ or analysis holding time have been exceeded.

BOD/CBOD:

Qualifiers K5, K6, & K8 indicate situations that may impact all results in an analytical run and should be used to qualify all affected samples as well as any affected quality control samples when reported.

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Laboratory fortified blank/blank spike:

Appropriate qualifier must be applied to the affected analytes in the Laboratory fortified blank/blank spike and to all corresponding analytes in the associated samples.

Matrix spike:

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Appropriate qualifier must be applied to the affected analytes in the matrix spike and should also be added to all corresponding analytes in the associated spiked sample. If a batch spike recovery is outside of the acceptable range, it is permissible to only flag the sample that was spiked and not the other samples in the batch. As required in the Arizona Adopted Rules A.A.C. R9-14-617.8.d, clients must always be informed if the batch QC result is unacceptable whether one of their samples was spiked or not. The laboratory can choose how the unacceptable QC is reported to the client (e.g., cover letter or flag).

The ADEQ policy 0154.000 can be accessed at http://www.azdeq.gov/function/business/download/spike8.pdf

General:

None.

Sample quality:

Flag samples with appropriate qualifier when sample quality may be potentially impacted or when method requirements were not met.
The ADEQ policy 0154.000 can be accessed at
http://www.azdeq.gov/function/business/download/spike8.pdf
The ADEQ policy 0155.000 can be accessed at
http://www.azdeq.gov/function/business/download/one_pt3.pdf

Duplicates:

For use with sample, matrix spike, LFB and LFB/blank spike duplicates. Qualify all affected analytes. For MS/MSD or sample duplicates qualify only the original source sample.

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Surrogate:

Qualify surrogates appropriately when they do not meet criteria. Surrogate failures in quality control samples will most likely require additional narration. S11 & S12 are used to qualify sample surrogates and only in cases where the Laboratory Fortified Blank/ blank spike has acceptable surrogate recoveries.

Method/analyte discrepancies:

For use with methods or analytes that are not currently approved under the Environmental Laboratory Licensure Rules or for which the lab is not licensed.

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Calibration verification:

Appropriate qualifier must be applied to all affected analytes in any samples associated with the calibration verification.
The ADEQ policy 0155.000 can be accessed at
http://www.azdeq.gov/function/business/download/one_pt3.pdf

Calibration:

None.

MDL STUDY

Columbia Analytical Services

Method Detection Limit Study

Analytical Method:	200.8/6020A
Extr./Dig. Method:	Red. Ppt.
Matrix:	Seawater
Units:	ug/L
Instrument:	K-ICP-MS-02
Analyst(s):	Greg Jasper

	Sample ID:	MDL-1	MDL-2	MDL-3	MDL-4	MDL-5	MDL-6	MDL-7	MDL-8
	Date Analyzed:	03/12/09	03/12/09	03/12/09	03/12/09	03/12/09	03/12/09	03/12/09	03/12/09
Analyte	Spike Level	Result 1	Result 2	Result 3	Result 4	Result 5	Result 6	Result 7	Result 8
Arsenic-75	0.050	0.0503	0.0571	0.0573	0.0503	0.0231	0.0528	0.0473	0.0485
Beryllium-9	0.001	0.001	0.0009	0.001	0.001	0.0011	0.0009	0.0009	0.001
Cadmium-114	0.001	0.0014	0.0013	0.0012	0.0013	0.0014	0.0017	0.0014	0.0014
Copper-63	0.025	0.0302	0.0213	0.0214	0.0167	0.0183	0.0159	0.0139	0.0138
Copper-65	0.025	0.0073	0.006	0.0078	0.0056	0.0072	0.0068	0.008	0.0089
Nickel-60	0.050	0.0662	0.0663	0.0636	0.0587	0.0454	0.055	0.0491	0.0547

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services
Method Detection Limit Study

Analytical Method: 200.8/6020A
Extr./Dig. Method: Red. Ppt.
Matrix: Seawater
Units: ug/L
Instrument: K-ICP-MS-02
Analyst(s): Greg Jasper
Sample ID:
Date Analyzed:

Analyte	Spike Level	Mean	Std Dev.	T-Value	MDL-C	MDL-R	% RSD	% Rec.	Spike/MDL	MDL Evaluation (Standard)
Arsenic-75	0.050	0.048	0.011	2.998	0.033	0.04	22%	97%	1.54	Valid MDL Data
Beryllium-9	0.001	0.001	0.000	2.998	0.000	0.0003	7%	98%	4.72	Valid MDL Data
Cadmium-114	0.001	0.001	0.000	2.998	0.000	0.0005	11%	139%	2.29	Valid MDL Data
Copper-63	0.025	0.019	0.005	2.998	0.016	0.02	29%	76%	1.54	Valid MDL Data
Copper-65	0.025	0.007	0.001	2.998	0.003	0.004	15%	29%	7.77	Valid MDL Data
Nickel-60	0.050	0.057	0.008	2.998	0.023	0.03	14%	115%	2.15	Valid MDL Data

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services

Method Detection Limit Study

Analytical Method: 200.8/6020A
Extr./Dig. Method: Red. Ppt.
Matrix: Seawater
Units: ug/L
Instrument: K-ICP-MS-02
Analyst(s): Greg Jasper
Sample ID:
Date Analyzed:

Analyte	Spike Level	Mean/MDL	MDL Evaluation - Water	MDL Evaluation - NonWater
			(DOD Quality Systems Manual Version 3 Protocol)	
Arsenic-75	0.050	1.49	N/A	Valid MDL Data
Beryllium-9	0.001	4.60	N/A	Valid MDL Data
Cadmium-114	0.001	3.17	N/A	Valid MDL Data
Copper-63	0.025	1.17	N/A	Valid MDL Data
Copper-65	0.025	2.24	N/A	Valid MDL Data
Nickel-60	0.050	2.46	N/A	Valid MDL Data

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services

Method Detection Limit Study

Analytical Method:	200.8/6020A
Extr./Dig. Method:	Red. Ppt.
Matrix:	Seawater
Units:	ug/L
Instrument:	K-ICP-MS-02
Analyst(s):	Greg Jasper

	Sample ID:	MDL-1	MDL-2	MDL-3	MDL-4	MDL-5	MDL-6	MDL-7	MDL-8	MDL-9	MDL-10
	Date Analyzed:	03/31/09	03/31/09	03/31/09	03/31/09	03/31/09	03/31/09	03/31/09	03/31/09	03/31/09	03/31/09
Analyte	Spike Level	Result 1	Result 2	Result 3	Result 4	Result 5	Result 6	Result 7	Result 8	Result 9	Result 10
Cadmium-111	0.010	0.0084	0.0074	0.0083	0.0087	0.0092	0.0086	0.0098	0.0082	0.0088	0.0094
Chromium-52	0.100	0.1112	0.1112	0.1171	0.1435	0.1186	0.1292	0.1311	0.121	0.1224	0.1173
Thallium-203	0.005	0.0064	0.0055	0.0061	0.0055	0.0061	0.0065	0.0063	0.0055	0.0057	0.0056
Thallium-205	0.005	0.0068	0.0055	0.0059	0.0056	0.0058	0.0063	0.0059	0.0055	0.006	0.0055
Zinc-66	0.200	0.252	0.24	0.2429	0.2338	0.2067	0.2028	0.2231	0.2063	0.2123	0.2018
Zinc-68	0.200	0.246	0.2331	0.2343	0.2293	0.2035	0.2047	0.2169	0.2024	0.2096	0.1983

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services
Method Detection Limit Study

Analytical Method: 200.8/6020A
Extr./Dig. Method: Red. Ppt.
Matrix: Seawater
Units: ug/L
Instrument: K-ICP-MS-02
Analyst(s): Greg Jasper
Sample ID:
Date Analyzed:

Analyte	Spike Level	Mean	Std Dev.	T-Value	MDL-C	MDL-R	% RSD	% Rec.	Spike/MDL	MDL Evaluation (Standard)
Cadmium-111	0.010	0.009	0.001	2.821	0.002	0.002	8%	87%	5.22	Valid MDL Data
Chromium-52	0.100	0.122	0.010	2.821	0.028	0.03	8%	122%	3.57	Valid MDL Data
Thallium-203	0.005	0.006	0.000	2.821	0.001	0.002	7%	118%	4.41	Valid MDL Data
Thallium-205	0.005	0.006	0.000	2.821	0.001	0.002	7%	118%	4.26	Valid MDL Data
Zinc-66	0.200	0.222	0.019	2.821	0.053	0.06	8%	111%	3.79	Valid MDL Data
Zinc-68	0.200	0.218	0.017	2.821	0.047	0.05	8%	109%	4.26	Valid MDL Data

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services

Method Detection Limit Study

Analytical Method:	200.8/6020A
Extr./Dig. Method:	Red. Ppt.
Matrix:	Seawater
Units:	ug/L
Instrument:	K-ICP-MS-02
Analyst(s):	Greg Jasper
Sample ID:	
Date Analyzed:	

Analyte	Spike Level	Mean/MDL	MDL Evaluation - Water	MDL Evaluation - NonWater
			(DOD Quality Systems Manual Version 3 Protocol)	
Cadmium-111	0.010	4.53	N/A	Valid MDL Data
Chromium-52	0.100	4.36	N/A	Valid MDL Data
Thallium-203	0.005	5.22	N/A	Valid MDL Data
Thallium-205	0.005	5.01	N/A	Valid MDL Data
Zinc-66	0.200	4.21	N/A	Valid MDL Data
Zinc-68	0.200	4.64	N/A	Valid MDL Data

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services

Method Detection Limit Study

Analytical Method:	200.8/6020A
Extr./Dig. Method:	Red. Ppt.
Matrix:	Seawater
Units:	ug/L
Instrument:	K-ICP-MS-02
Analyst(s):	Greg Jasper

	Sample ID:	MDL-1	MDL-2	MDL-3	MDL-4	MDL-5	MDL-6	MDL-7	MDL-8	MDL-9	MDL-10
	Date Analyzed:	04/28/09	04/28/09	04/28/09	04/28/09	04/28/09	04/28/09	04/28/09	04/28/09	04/28/09	04/28/09
Analyte	Spike Level	Result 1	Result 2	Result 3	Result 4	Result 5	Result 6	Result 7	Result 8	Result 9	Result 10
Cobalt-59	0.0025	0.0042	0.0042	0.0042	0.0044	0.0040	0.0034	0.0041	0.0045	0.0043	0.0045
Lead-208	0.025	0.0253	0.0239	0.0245	0.0251	0.0247	0.0171	0.0198	0.0247	0.0247	0.0262
Silver-107	0.005	0.0102	0.0082	0.0095	0.0085	0.0079	0.0081	0.0077	0.0084	0.0078	0.0111
Silver-109	0.005	0.0093	0.0084	0.0092	0.0082	0.0077	0.0081	0.0074	0.0077	0.0074	0.0104

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services

Method Detection Limit Study

Analytical Method: 200.8/6020A
Extr./Dig. Method: Red. Ppt.
Matrix: Seawater
Units: ug/L
Instrument: K-ICP-MS-02
Analyst(s): Greg Jasper
Sample ID:
Date Analyzed:

Analyte	Spike Level	Mean	Std Dev.	T-Value	MDL-C	MDL-R	% RSD	% Rec.	Spike/MDL	MDL Evaluation (Standard)
Cobalt-59	0.0025	0.004	0.000	2.821	0.001	0.0009	8%	167%	2.78	Valid MDL Data
Lead-208	0.025	0.024	0.003	2.821	0.008	0.009	12%	94%	3.11	Valid MDL Data
Silver-107	0.005	0.009	0.001	2.821	0.003	0.004	13%	175%	1.55	Valid MDL Data
Silver-109	0.005	0.008	0.001	2.821	0.003	0.003	12%	168%	1.82	Valid MDL Data

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services

Method Detection Limit Study

Analytical Method:	200.8/6020A
Extr./Dig. Method:	Red. Ppt.
Matrix:	Seawater
Units:	ug/L
Instrument:	K-ICP-MS-02
Analyst(s):	Greg Jasper
Sample ID:	
Date Analyzed:	

Analyte	Spike Level	Mean/MDL	MDL Evaluation - Water	MDL Evaluation - NonWater
			(DOD Quality Systems Manual Version 3 Protocol)	
Cobalt-59	0.0025	4.64	N/A	Valid MDL Data
Lead-208	0.025	2.94	N/A	Valid MDL Data
Silver-107	0.005	2.70	N/A	Valid MDL Data
Silver-109	0.005	3.05	N/A	Valid MDL Data

Supervisor Approval _____

QA Approval _____

Columbia Analytical Services

Method Detection Limit Study **Verification**

Analytical Method: 200.8/6020A
Extr./Dig. Method: Red. Ppt.
Matrix: Seawater
Units: ug/L

Instrument: K-ICP-MS-02
Analyst(s): Greg Jasper

Sample ID: MDL Ver-1 MDL Ver-2 MDL Ver-3 MDL Ver-4
Date Analyzed: 3/12-4/28/2009

Analyte	MDL	Spike Level	Result 1	Result 2	Result 3	Result 4	s/n >3 ? Y/N	Qualitative I.D.? Y/N
Arsenic-75	0.04	0.050	**0.0304**					Y
Beryllium-9	0.0003	0.001	**0.0005**					Y
Cadmium-111	0.002	0.010	**0.0076**					Y
Cadmium-114	0.0005	0.005	**0.0012**					Y
Chromium-52	0.15/14/4	~~0.04~~ 0.03	0.100	**0.0755**				Y
Cobalt-59	0.0009	0.003	**0.0032**					Y
Copper-63	0.02	0.025	**0.0128**					Y
Copper-65	0.004	0.025	**0.0051**					Y
Lead-208	0.009	0.013	**0.0114**					Y
Nickel-60	0.03	0.050	**0.0217**					Y
Silver-107	0.004	0.010	**0.0058**					Y
Silver109	0.003	0.0025	**0.0058**					Y
Thallium-203	0.002	0.0025	**0.004**					Y
Thallium-205	0.002	0.005	**0.004**					Y
Zinc-66	0.06	0.200	**0.1071**					Y
Zinc-68	0.06	0.200	**0.1055**					Y

Supervisor Approval _____

QA/QC Approval _____

LCS Data

	TRUE (ug/L)	Found (ug/L)	%R
Arsenic	2.0	1.85	92.5
Copper	2.0	1.89	94.5
Lead	2.0	1.97	98.5
Arsenic	2.0	1.76	88.0
Copper	2.0	1.91	95.5
Lead	2.0	2.01	100
Arsenic	2.0	2.05	102
Copper	2.0	1.94	97.0
Lead	2.0	1.97	98.5

CRDL Standard Data

	TRUE (ug/L)	Found (ug/L)	%R
Arsenic	5.0	4.26	85.2
Copper	1.0	1.08	108
Lead	0.2	0.18	90.0
Arsenic	5.0	4.88	97.6
Copper	1.0	1.00	100
Lead	0.2	0.208	104
Arsenic	5.0	5.01	100
Copper	1.0	1.30	130
Lead	0.2	0.236	118

RedPrec_W_LCS_2009

Matrix	Prep Meth	Arsenic	Beryllium	Cadmium	Chromium	Cobalt	Copper	Lead	Nickel	Silver	Thallium	Zinc
	Count	25	4	14	16	2	36	22	35	15	6	22
	Average	92.66	93.25	101.79	99.81	100.00	94.69	100.86	99.86	97.60	97.83	103.91
	Std Dev	7.84	6.70	3.02	3.67	2.83	14.97	3.81	2.86	3.20	3.49	4.15
	UCL	116	113	111	111	108	140	112	108	107	108	116
	LCL	69	73	93	89	92	50	89	91	88	87	91

RedPrec W LCS	n	UCL	LCL
Arsenic	25	116	69
Beryllium	4	113	73
Cadmium	14	111	93
Chromium	16	111	89
Cobalt	2	108	92
Copper	36	140	50
Lead	22	112	89
Nickel	35	108	91
Silver	15	107	88
Thallium	6	108	87
Zinc	22	116	91

Limits generated 6/23/09

APPENDIX E

CTDEP MEETING MINUTES, APPROVAL OF ALTERNATIVE SWPC, AND RESPONSES TO COMMENTS

Rich, Corey

From: Lewis, Mark [Mark.Lewis@ct.gov]
Sent: Thursday, May 21, 2009 4:51 PM
To: Rich, Corey; james.gravette@navy.mil
Cc: Balsamo, Nina; Keckler.Kymberlee@epamail.epa.gov; Conant, Richard CIV NAVFAC MIDLANT; Glorieux, Jean-Luc; Gatter-Evarts, Rosemary; Warzecha, William
Subject: Lower Subase FS - Summary of May 20, 2009 Copper/Arsenic Conference Call

Corey and Jim-

Thank you to you and the rest of the Navy team for participating in yesterday's conference call to work out the details of the copper/ arsenic issue for groundwater in the Lower Base. DEP truly appreciates the Navy's efforts to respond to DEP's concerns. The purpose of this e- mail is to summarize yesterday's discussion, and the agreements that were reached. Please feel free to respond with any clarifications, additions or questions.

Call Participants:

US Navy

Jim Gravette- RPM
Dick Conant- Subase Environmental Dept.

Tetra Tech

Corey Rich
Nina Balsamo
John- Luc Glorieux

CTDEP

Bill Warzecha- Supervisor- Remediation Division, Eastern District
Rosemary Matter- Evarts- Environmental Analyst- Aquatic Toxicity Program
Mark Lewis- Subase Project Manager

The group discussed the material presented at the May 14, 2009 meeting at EPA's Region 1 office in Boston as "Topic 3 Item A." Corey Rich of Tetra Tech sent this presentation to the group on May 7, 2009 via an e- mail with the subject line "May 14, 2009 Meeting - Topic 3 Lower Subase Feasibility Study Item A".

Summary of Previous Discussions

The group has participated in several previous discussions on this topic. During the March 16, 2009 meeting at EPA's Region 1 office in Boston the Navy distributed two memoranda summarizing the existing copper/ arsenic data for groundwater in the Lower Base. Groundwater in the Lower Base was sampled in studies conducted in 1991, 1993, 1994 (2 studies), and 1997. In February 2009, DEP approved the Navy's request for an alternative surface water protection criterion (SWPC) for arsenic of 10 µg/l. The default SWPC of 48µg/l for copper remains in effect. Both of these metals have been detected at concentrations greater than their respective criteria in previous sampling rounds. The Navy suggested that some of the copper and arsenic detected in previous samples may have been false positives caused by turbidity and/ or matrix interference due to salinity. During an April 2, 2009 conference call between DEP and the Navy, the Navy agreed to redevelop selected wells and collect two additional rounds of samples. This proposal is summarized in the "Topic 3 Item A" handout.

Purpose of Sampling and Frequency of Additional Sampling

Mark Lewis of DEP noted that the Navy had previously agreed to conduct two additional rounds of groundwater sampling pursuant to Section 22a-133k-3(f)(2)(B) of the Remediation Standard Regulations. This section of the RSRs allows compliance with the surface water protection criteria to be demonstrated based on the concentration in the portion of the plume immediately upgradient of the point where the groundwater discharges to surface water, providing certain conditions are met. Mark explained that this section of the regulations applies to a situation where contaminants are present at concentrations exceeding the SWPC on the upgradient portion of a site, but due to natural attenuation, the concentrations decrease to a concentration less than the SWPC at the point of discharge to surface water. This assumes that the plume is at steady state and that there is not a "slug" of contamination that has travelled past the upgradient portion of the site but has not yet reached the discharge point to surface water. This also assumes that the site is well characterized and there is enough data collected over a sufficient period of time to say that the concentrations of contaminants at the surface water discharge point have reached steady state and are not expected to increase.

Corey Rich pointed out that the purpose of the current feasibility study is to characterize the nature and extent of contamination. He noted that the Navy is not yet at the point of demonstrating compliance with the RSRs. Jean-Luc also noted that there is not a defined "plume" of contamination, but there are scattered exceedances of the SWPC for Cu and As in Zone 1 and for As in Zones 4, 5, and 7. DEP agreed that this was a valid point. DEP suggested, however, that it might be prudent for the Nay to collect more than two quarters of additional sampling data. If there are no exceedances of the SWPC in four consecutive quarterly rounds of sampling, then the Navy will not need to take further action to address copper and arsenic in groundwater.

Monitoring Locations and Need for Additional Monitoring Wells

The group discussed the location of the existing wells that the Navy proposes to include in the monitoring program, and the need for installation of additional monitoring wells. In general, DEP agreed that all of the existing wells the Navy proposes to monitor are appropriate. DEP requested that the Navy install a total of two additional wells. The Navy would install one additional well in the most downgradient portion of Zone 1 (possibly at the former location of 13MW7), and the other in one in the most downgradient portion of Zone 5 (possibly at the former location of 19MW4. The Navy agreed to conduct two additional rounds of sampling, and to evaluate whether to conduct additional rounds of sampling beyond he two already proposed. The Navy also stated that they need to consider whether it makes sense to install permanent wells, or to install temporary wells separately for each round of sampling. Among the considerations listed by the Navy are the long- term cost, the need to avoid interfering with operations in the Lower Base Area, and whether wells installed permanently would require long term maintenance, and whether such wells might provide useful data as part of whatever remedy is selected for the Lower Base. The Navy and DEP agreed that the Navy did not need to install additional wells in Zones 4 or 7.

DEP will be closed tomorrow due to a furlough day. I will be out of the office on Tuesday for training, but will be checking my voice mail at some point during the day. If any urgent issues arise, please contact Bill Warzecha via e- mail or at (860) 424-3776. If Bill is unavailable, the general number for the Remediation Division is (860) 424- 3705.

Have a great holiday weekend.

Regards,

Mark

Mark R. Lewis
Environmental Analyst
Connecticut Department of Environmental Protection
Bureau of Water Protection and Land Reuse
Remediation Division/ Eastern District

79 Elm St.
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mark.lewis@ct.gov

Rich, Corey

From: Gatter-Evarts, Rosemary [Rosemary.Gatter-Evarts@ct.gov]
Sent: Tuesday, February 03, 2009 2:29 PM
To: Rich, Corey; richard.conant@navy.mil; valdis.jurka@gmail.com
Cc: Lewis, Mark; Iott, Traci
Subject: RE: Alternative SWPC for Arsenic - Phase II RI Biota Data

Corey et al,

I stated that the 36 ug/l for arsenic may be acceptable but I needed additional time to review the report submitted by Jim Citak in Aquaculture. Upon more careful review and consultation with others at DEP it was determined that we could most likely not approve a 36 ug/l arsenic value since it would preclude a designated use of the Thames River, i.e fishable and swimmable. Although it appear that the arsenic in the groundwater is not impacting the shellfish beds on the other side of the river, the human health based water quality criteria is based on the consumption of aquatic organisms including both shellfish and finfish , applies to the river in general. Allowing the concentration of arsenic to exceed water quality criteria outside the established zone of influence would be inconsistent with the Water Quality Standards and programs like the Remediation Program which, in part, implements the Standards into practice. That being said , the Department will allocate the 100:1 dilution factor for the assimilation of arsenic for all zones which brings the alternative surface water protection for arsenic to 6.3 ug/l using the human health based water quality criteria and an adjustment factor for application of the criteria to 7Q10 flows. This value, however, may be below the concentration that could be reliably quantified using laboratory methods. The Department proposes to approve 10 ug/l as the Alternative Surface water Protection criteria for all zones at account for both water quality issues and analytical concerns.

From: Rich, Corey [mailto:Corey.Rich@tetratech.com]
Sent: Tuesday, February 03, 2009 11:01 AM
To: Conant, Richard CIV NAVFAC MIDLANT; Lewis, Mark; Jurka, Val CIV NAVFAC Atlantic, Ev33; valdis.jurka@gmail.com; Gatter-Evarts, Rosemary
Cc: Glorieux, Jean-Luc; Balsamo, Nina
Subject: Alternative SWPC for Arsenic - Phase II RI Biota Data

Team,

Per the CTDEP's request, the attached files (Sample Location Map, Positive Detection Table, and Text) summarize the biota data that was collected during the Phase II RI. The data includes oyster and clam samples from commercial beds, native blue mussels from various locations in the Thames River, and ribbed mussels that were used in cage studies adjacent to the Subase. A summary of the arsenic concentrations in the samples is provided below.

(1) Arsenic in Commerical and Native Biota Samples (Oysters, Clams, and Blue Mussels): 16 samples, Concentration Range: 0.9 to 6.7 mg/kg.

(2) Arsenic in Caged Mussel Samples (Ribbed Mussels): 9 camples, Concentration Range: 0.61 to 1.0 mg/kg.

All of the arsenic concentrations are well below the FDA levels (76 and 86 mg/kg) for arsenic suggested for use to screen the data by CTDEP. Therefore, the Subase does not appear to have impacted arsenic concentrations in shellfish in the area of the Subase. Therefore, the Navy's recommended Alternative SWPC of 36 ug/L (CTDEP WQS chronic, saltwater) would be protective of human health and the environment.

Please review the attached information and provide your concurrence or additional comments/questions.

Regards,

Corey Rich | Senior Project Manager/Civil Engineer
Direct: 412.921.8984 | Main: 412.921.7090 | Fax: 412.921.4040
Corey.Rich@tetratech.com

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Rich, Corey

From: Rich, Corey
Sent: Wednesday, March 24, 2010 4:08 PM
To: 'Conant, Richard CIV NAVFAC MIDLANT'; Gravette, James CIV NAVFAC; Keckler.Kymberlee@epamail.epa.gov; Lewis, Mark; Kenneth_Munney@fws.gov; Ken.Finkelstein@noaa.gov; gkemp@gfnet.com; rtfinlayson@gfnet.com; Hoskins.Bart@epamail.epa.gov; Wright, Jennifer H CIV NAVFAC Lant; Bernhardt, Aaron
Cc: Stackpole, Andrew CIV NAVFAC MIDLANT; Hamel, Maurice; Glorieux, Jean-Luc
Subject: RE: New London - IR Team Production Call on March 24 (0930-1100) - Agenda, Call-in #, and Tasker List

Team,

Thank you for everyone's participation and discussions today during our production call. We were able to make progress on some difficult topics. The three topics discussed during the call included the following: (1) CTDEP input on Engineered Control waiver/variance, (2) Groundwater UFP-SAP RTCs, and (3) Tasker List. A brief summary of the items discussed and action items/decisions reached during the call is provided below.

(1) CTDEP input on Engineered Control waiver/variance: Maurice Hamel, CTDEP, discussed the State's position. He indicated that the CTDEP RSRs would allow for engineered controls that consider alternative approaches to cover material (asphalt/concrete) without the need for a variance/waiver. He said that additional calculations were necessary to support the use of the alternative cover material. The calculations should consider infiltration rates through existing or proposed cover material, chemical-specific leachability data (e.g., SPLP data), and other site information (groundwater dilution) to determine the potential impact of soil leachate on the underlying groundwater. The goal would be to show that the existing asphalt cover would sufficiently reduce infiltration and leachate and be protective of groundwater. If the calculations do not show protectiveness, another approach (e.g., improve the quality of the asphalt) would need to be evaluated. Maurice suggested that the Navy/Tetra Tech contact him if they have any questions. Maurice also said to consider site features that may affect infiltration and contaminant migration (e..g, site grading and storm sewers) in the evaluation. The team agreed that the following steps should be taken: the calculation will be performed and a summary tech memo will be prepared, the information will be submitted to the team for review and approval, and the final calculation/tech memo will be incorporated into the final Lower Subase FS.

(2) Groundwater UFP-SAP RTCs: EPA's February 16, 2010 comment letter, March 23, 2010 comment email, and March 23, 2010 comment letter were discussed. The Navy issued a RTC document on March 5, 2010 that responded to the February 16, 2010 comment letter. The major agreement reached during the discussion was that the current groundwater SAP, with minor changes, is sufficient to proceed but additional groundwater data collection will likely be required post-ROD as part of another groundwater PDI or as part of the groundwater monitoring programs that will be implemented. The details of any additional groundwater sampling will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated. Other minor issues were discussed and resolved and will be captured in revised RTC documents. Tetra Tech will prepare a revised RTC document and issue it by March 31, 2010. CTDEP's March 2, 2010 comment letter and the Navy's March 9, 2010 RTC document were also discussed. The CTDEP generally concurred with the responses provided during the discussion. The CTDEP will complete their review of the RTCs and provide their formal concurrence by March 31, 2010. Assuming CTDEP concurrence is received on that date, a redline version of GW SAP will be prepared and issued on April 2, 2010. Regulators will review/approve redline version by April 12, 2010 and the final GW SAP would be issued by April 21, 2010. Assuming these dates are met, the field work associated with the GW SAP is expected to begin the last week in April 2010 or first week in May 2010.

(3) Tasker List: Due to the limited time available at the end of the call, the Navy reviewed only the major items included in the tasker list. It was recommended that the team review the entire tasker list and provide the Navy with any comments.

Hopefully, I captured the information correctly. Please let me know if you have any questions/comments.

Regards,

Corey Rich | Senior Project Manager/Civil Engineer
Direct: 412.921.8984 | Main: 412.921.7090 | Fax: 412.921.4040 Corey.Rich@tetratech.com

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-----Original Message-----
From: Conant, Richard CIV NAVFAC MIDLANT [mailto:richard.conant@navy.mil]
Sent: Friday, March 19, 2010 7:29 AM
To: Gravette, James CIV NAVFAC; Keckler.Kymberlee@epamail.epa.gov; Lewis, Mark; Kenneth_Munney@fws.gov; Ken.Finkelstein@noaa.gov; gkemp@gfnet.com; rtfinlayson@gfnet.com; Hoskins.Bart@epamail.epa.gov; Wright, Jennifer H CIV NAVFAC Lant; Bernhardt, Aaron; Rich, Corey
Cc: Stackpole, Andrew CIV NAVFAC MIDLANT
Subject: RE: New London - IR Team Production Call on March 24 (0930-1100) - Agenda, Call-in #, and Tasker List
Importance: High

New London IR team,

Below is the call-in number for the March 24 (0930-1100) production call. We are planning to concentrate our discussion on resolution the GW SAP comments. I have attached the RTC's we sent out to EPA and CTDEP on 3/5/10 and 3/9/10, respectively. We will also review the updated IRP tasker list, see attached.

Call-in number information is provided below:

Date/Time: March 24, 2010 at 09:30 AM

Length: 90 minutes

Meeting ID: 3466

Phone Number: 1-866-270-2016 (US Toll Free)Date/Time:

R/Dick

RESPONSES TO EPA FEBRUARY 16, 2010 COMMENTS
AND MARCH 23, 2010 REBUTTALS
DRAFT SAMPLING AND ANALYSIS PLAN
UFP-SAP FOR PRE-DESIGN GROUNDWATER SAMPLING AT LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

INITIAL ISSUE: March 5, 2010
REVISION 1 ISSUE: March 31, 2010

General Comment (GC) 1:

The document states that the scope of the groundwater sampling effort for the pre-design investigation (PDI) was resolved during several partnering meetings. However, those discussions that are referenced focused primarily on issues raised by the State and were understood to be components of the PDI but not the entirety of the PDI. These discussions were also held before the development of the Draft Final Feasibility Study (FS) and the availability of the results of the kriging effort that was critical to identifying areas of contamination and potential contamination. Therefore, the PDI needs to be revised to allow it to provide the data required to reduce the uncertainty currently inherent in the understanding of the extent of contamination so that the next iteration of kriging will be robust enough to prepare a remedial design that EPA can support.

Response:

During the comment and comment resolution periods for the draft Lower Subase Feasibility Study, the only regulator concern raised regarding the groundwater data set was for the matrix interference issue for several metals (arsenic, lead, and copper) in select zones of the Lower Subase. The extent of the Groundwater Pre-Design Investigation (PDI) was extensively discussed during the March 16, 2009 and May 14, 2009 Partnering Meetings and two conference calls on April 2, 2009 and May 20, 2009. EPA did not participate in the conference calls, but was provided minutes that summarized both calls. EPA provided recommendations on the additional soil sampling required at the Lower Subase during this time, but did not provide any recommendations regarding groundwater sampling. The new issues raised by EPA would significantly delay implementation of the Groundwater PDI Sampling and Analysis Plan (SAP) and selection of final remedies for groundwater. The Navy believes that the existing data supplemented by the new data to be collected under this Groundwater PDI SAP is sufficient to move forward to a Proposed Plan and Record of Decision. The Navy intends to proceed with the currently proposed sampling program and minimize additional impacts to the project schedule.
The kriging referenced by EPA was conducted for soil data. The results of kriging historical soil data cannot be used to directly determine that additional groundwater sampling is required. Existing groundwater data and contaminant fate and transport parameters should be considered to determine potential mobility concerns. Based on the draft final Lower Subase Feasibility Study, which considered these factors, only arsenic, copper, lead, and TPH are groundwater contaminants of concern for the Lower Subase. Therefore, the currently proposed sampling program is adequate.

EPA Rebuttal:

EPA does not agree that the scope of the groundwater PDI was extensively discussed during team meetings. The principal issue discussed was the CTDEP's concern regarding the metals concentrations in the groundwater at Zone 1. The scope of the groundwater PDI was not presented during those meetings. EPA expected the scope of the PDI to consider the results of the kriging effort that was proposed and incorporated into the Draft Final Feasibility Study as well as follow up sampling to refine the extent of LNAPL and potential hot spots, especially considering the age of the groundwater data available for evaluation. The available groundwater data together with the groundwater sampling proposed are not sufficient to adequately characterize current site groundwater and not sufficient to support remedy selection or remedial design.

Response to Rebuttal:

Per discussions conducted during the March 24, 2010 Production Meeting, the Navy and EPA agreed that additional groundwater data collection may be required post-ROD to address remaining data gaps as part of another groundwater PDI or as part of the groundwater monitoring programs that will be implemented as part of the groundwater remedies. The details of any additional groundwater sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

GC2:

The SAP does not include any sampling for total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) or evaluation of wells for the presence of NAPL, especially LNAPL. Based on the initial kriging results for soil, hot spots were identified that could be continuing sources of groundwater contamination. The magnitude and extent of groundwater contamination associated with these hot spots is not well defined and therefore is not complete enough to develop an adequate remedial design or define the extent of groundwater contamination sufficiently for a decision document. Reliance on groundwater data collected in 1997 or earlier without consideration of the kriging results is not appropriate. EPA notes that the FS identified 2,500 μg/L TPH as an alternative surface water protection criterion based on an existing stormwater general permit. Finally, the FS includes alternatives for treatment of TPH in Zones 4 and 7. Additional zones may also require treatment for TPH based on additional sampling of suspect areas in those zones during the PDI.

Response:

TPH was identified as a groundwater contaminant of concern based on the current data set. It is believed that the current data set is sufficient to select remedies. The preferred remedies for soil and groundwater will include groundwater monitoring; therefore, additional sampling is not needed for remedy selection or remedial design.

PAHs were not identified as groundwater contaminants of concern in the draft final Lower Subase Feasibility Study; therefore, further sampling for them is not warranted.

See Response to GC1 regarding the use of soil kriging results to identify groundwater contaminants of concern.

The treatment alternatives included in the draft final Lower Subase FS are included to provide a full range of remedial alternatives. The Navy has discussed its preferred alternative(s) for groundwater (land use controls and monitoring) with the team (EPA and CTDEP) and does not believe it is necessary to collect additional data to further evaluate treatment alternatives that will not be implemented.

EPA Rebuttal:

The approach suggested in the response, that monitoring as a component of remedy implementation can substitute for adequate site characterization, is an unusual approach and contrary to the response, is not supportive of decision making. The approach would have to require a significantly greater monitoring program without the appropriate site characterization, as compared to the monitoring program required following an appropriate groundwater characterization effort before design.

Response to Rebuttal:

Per discussions conducted during the March 24, 2010 Production Meeting, the Navy and EPA agreed that additional groundwater data collection may be required post-ROD to address remaining data gaps as part of another groundwater PDI or as part of the groundwater monitoring programs that will be implemented as part of the groundwater remedies. The details of any additional groundwater sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

GC3:

The Draft Final FS presented a hypothesis that establishes the potential presence of NAPL based on the concentration of TPH in soil. This hypothesis is an alternative method for determining the potential presence of NAPL to the method stipulated in the Connecticut Remediation Regulations (CT RSR). There is little empirical evidence currently available to support the hypothesis at the Lower Subase. The PDI should confirm this hypothesis with representative data from the zones where NAPL could be present based on historical site use and data. Please edit the scope of the PDI to address this.

Response:

The scientific approach taken by the Navy to identify NAPL is well founded and more rigorous than the method identified in the Connecticut RSRs. The presence of NAPL in Zone 1 was confirmed by field measurements in the area where the calculations indicated NAPL should be present. The monitoring wells included in the Groundwater PDI SAP will be checked for NAPL as

part of the standard well evaluation process conducted prior to sampling each well, but it is unlikely NAPL will be present because a well inventory conducted and documented in a September 2007 Monitoring Well Inventory Report (Tetra Tech) did not identify free product in these wells or other wells in the Lower Subase. Because no new wells are proposed to be installed, the extent of NAPL in Zone 1 will be confirmed during the forthcoming soil PDI. Information collected during the soil PDI (e.g., stained soil and TPH concentrations) will be used to identify and approximate the extent of the NAPL. The Soil PDI SAP will be submitted to the EPA and project team for review and comment in March 2010.

EPA Rebuttal:

There is no basis to state that the methodology used by the Navy is more rigorous than the method identified in the Connecticut regulations. In fact, there is information in the literature that supports the methodology in the Connecticut regulations and it is well known that the solubility of chemicals in multi-chemical environments is significantly less than the solubility in single chemical environments. The groundwater investigation is not adequate to assess the presence of NAPL in areas potentially impacted by NAPL or to confirm the adequacy of the TPH thresholds used in the evaluation. Moreover, the presence of NAPL also impacts the cleanup goals for other contaminants.

Response to Rebuttal:

The Soil PDI includes an extensive sampling program to help delineate the extent of LNAPL in Zone 1. Monitoring wells included in the groundwater PDI will also be checked for LNAPL as part of the evaluation efforts conducted prior to sampling. Per discussions conducted during the March 24, 2010 Production Meeting, the Navy and EPA agreed that additional data collection may be required post-ROD to address remaining data gaps as part of another PDI. The details of any additional sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

GC4:

Please note that EPA Region 1 has updated the low flow sampling protocol. Please use this revised protocol for any groundwater sampling conducted at the Lower Subase. Please refer to document EQASOP-GW 001 Revision Number 3, dated January 19, 2010. In addition, a revised calibration procedure has also be issued. Refer to document EQASOP-FieldCalibrat Revision Number 2 also dated January 19, 2010.

Response:

EPA's new SOPs on low flow sampling protocol and calibration procedures will be incorporated into the Groundwater PDI SAP.

GC5:

If Navy has a mandate to evaluate a clean closure alternative, as it has stated in the past, then groundwater investigation beyond that which is included in this SAP is required. Please explain why the SAP is not constructed to provide the data required to evaluate a clean closure alternative.

Response:

Because of several factors [groundwater classification (GB), high salinity of groundwater, and availability of potable water], a clean closure groundwater alternative is not practical for the Lower Subase zones. EPA's risk assessor reviewed and approved the exposure scenarios considered in the most recent human health risk assessment included in the Lower Subase FS. Therefore, no changes are necessary in response to this comment.

GC6:

If the ultimate remedy for the Lower Subase will be the establishment of engineering controls and site use/activity restrictions, then it is imperative that a thorough and up-to-date characterization of the groundwater quality be determined to support and lend credibility to that plan.

Response:

The existing groundwater data, along with the zone boundaries and natural boundaries (e.g., Thames River), provide reasonable limits for establishment of engineering controls. Therefore, no changes are necessary in response to this comment.

EPA Rebuttal:

As stated previously, EPA does not agree that the existing and proposed groundwater data are adequate to properly characterize the site groundwater for decision-making, especially considering that the preferred remedial approach is engineering controls and site use restrictions. More effort is required to update the current groundwater database by installation of additional wells and sampling of more existing wells.

Response to Rebuttal:

Per discussions conducted during the March 24, 2010 Production Meeting, the Navy and EPA agreed that additional groundwater data collection may be required post-ROD to address remaining data gaps as part of another groundwater PDI or as part of the groundwater monitoring programs that will be implemented as part of the groundwater remedies. The details of any additional groundwater sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

GC7:

Has Navy considered collecting soil samples during the installation of the proposed groundwater monitoring wells?

Response:

The two new monitoring wells proposed for the Groundwater PDI will be installed in the same locations as historic wells. Therefore, collection of soil samples from these borings would not provide significant new data. A Soil PDI SAP is currently being prepared and it recommends an extensive soil sampling program for all seven zones in the Lower Subase. EPA's recommendations on the additional soil sampling required at the Lower Subase were considered during preparation of the SAP. The SAP will be submitted to the EPA for review and comment in March 2010.

EPA Rebuttal:

All site data are old and the Navy is missing an opportunity by not including soil sampling during well installation. EPA is currently reviewing the soil PDI plan.

Response to Rebuttal:

The draft Soil PDI Work Plan was submitted to the EPA on March 19, 2010. The Work Plan includes an extensive soil sampling program without data from the two proposed wells. New soil data from these wells would provide little new information.

Per discussions conducted during the March 24, 2010 Production Meeting, the Navy and EPA agreed that additional data collection may be required post-ROD to address remaining data gaps. The details of any additional sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

Two additional monitoring wells were identified by EPA as not being located in the 2007 Monitoring Well Inventory; 13MW15 and 20MW7. These two wells will be re-installed and designated as MW1-4PDI and MW1-7PDI, respectively. These well will be located in the same locations, and screened over the same depths, as the original two wells.

GC8:

The proposed sampling and analysis takes a well-motivated approach to verify previous results and to reduce sources of uncertainty. In particular, previous analytical results have been questioned because of the matrix effects as a consequence of elevated turbidity and salinity. The proposed effort will include both unfiltered ("total") and filtered ("dissolved") samples in order to identify and minimize the effects of turbidity. The analysis is to be performed by ICP-MS (method 6020B) in order to minimize the effects of high salinity and to achieve adequate detection limits.

Response:

Comment noted. To clarify, the project laboratory will perform a two-step method to address matrix interference issues and analyze the groundwater samples. Method 1640 is a preparatory method that will be performed by the laboratory to address matrix interferences and Method 6020 will be used by the laboratory to determine the concentrations of the metals in the groundwater samples.

GC9:

The SAP proposes analyses only for "select metals" (e.g., p. 47, Worksheet #15). However, given that there are outstanding questions regarding the reliability of previous analytical results, it is recommended that all samples be analyzed for the complete TAL, for which previous results are equally suspect. The additional data may be valuable in the interpretation of data for the primary elements of concern (i.e., arsenic, copper, and lead). For example, it may be interesting to seek evidence for the origin of the elevated arsenic at the site. If the arsenic is mobilized from hydrous ferric oxides within the aquifer under reducing conditions, a correlation between iron and arsenic may be likely. Without the supporting data for additional metals, this type of interpretation will not be possible.

Response:

The reduced list of metals to be analyzed for during the Groundwater PDI is sufficient to address the existing data gaps. Water quality data collected during the groundwater purging/collection process (e.g., oxidation-reduction potential and pH) will be useful for determining the geochemical conditions affecting the state of arsenic present in the groundwater and its potential for mobilization.

EPA Rebuttal:

Besides the concerns related to matrix interferences for existing inorganic site data, the existing groundwater data are obsolete (12 to 15 years old) and not useful for characterizing current groundwater conditions at the site. Reliance on this data alone to establish the scope of the groundwater PDI is inappropriate.

Response to Rebuttal:

Per discussions conducted during the March 24, 2010 Production Meeting, the Navy and EPA agreed that additional groundwater data collection may be required post-ROD to address remaining data gaps as part of another groundwater PDI or as part of the groundwater monitoring programs that will be implemented as part of the groundwater remedies. The details of any additional groundwater sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

GC10:

EPA recommends that the following steps be taken to minimize analytical concerns from the anticipated salinity of the groundwater samples:

- Measure and record salinity at the end of the purge, as already specified in the SAP (e.g., p. 42, Worksheet #14). Transmit the salinity data to the analytical lab when the samples are submitted, so that the lab can consider the salinity in planning the appropriate calibrations and analytical approaches on a sample-by-sample basis.

- Alert the analytical lab in advance to the potential issues with matrix interference from salinity so that the lab can anticipate the necessary adjustments and optimize their procedures to meet required reporting limits and project objectives.

Response:

Recommendations noted. The laboratory and analytical methods chosen for this project were specifically selected because they can address the matrix interference from salinity issue. The project laboratory [Columbia Analytical Services (Kelso)] is one of only a few laboratories in the United States that are approved to do this type of analysis. Salinity data will be collected during the purging and sampling of the groundwater wells and recorded on the groundwater sample log sheets. This data will be provided to the laboratory if it is determined to be necessary.

EPA Rebuttal:

Please confirm that preparation method 1640 will be conducted for all groundwater samples collected irrespective of the groundwater salinity.

Response to Rebuttal:

The project laboratory will conduct Method 1640 for all groundwater samples regardless of the salinity.

SPECIFIC COMMENTS – APPENDIX A

Specific Comment (SC) 1: p. 8, Worksheet #2

Please delete EPA from the list of participants for the May 20, 2009 conference call.

Response:

Agree. EPA will be removed from the list of participants for the May 20, 2009 conference call in Worksheet #2. EPA did not participate in the call, but was subsequently provided with minutes for the meeting.

SC2: p. 26, §10.1.2.1, ¶2

Please correct the figure reference to Figure 10-4. It appears that all the figure number references in Section 10.1.2 starting with 10-3 are off by a digit. Please correct (Section 10.1.2.1 Zone 1 should reference Figure 10-4, Section 10.1.2.2 Zone 4 should reference Figure 10-5, Section 10.1.2.3 Zone 5 should reference Figure 10-6, Section 10.1.2.4 Zone 7 should reference Figure 10-7, and Section 10.2 should reference Figure 10-8.).

Response:

Agree. The figure numbers will be corrected as recommended. In addition, the following sentence will be added to the second paragraph in Subsection 10.1.2.1:

"...ground surface (bgs). Figure 10-3 shows the locations of geological cross sections through Zones 1, 4, 5, and 7. Figure 10-4 depicts the geological cross section through Zone 1."

SC3: p. 33, §11.1, ¶3

Please note that the FS includes groundwater treatment alternatives for arsenic, copper, lead, and TPH. Please explain why TPH is not addressed in this SAP.

Response:

See Response to GC2.

SC4: p. 35, §11.4

a) The third bullet cites funding and schedule restraints as a factor in determining the scope of this PDI. While that is understandable, it cannot justify not completing an appropriate PDI before submittal of a remedial design. If currently available funding will restrict this initial PDI effort then EPA expects a supplemental PDI to address its concerns before submitting a remedial design.
b) The first sentence in the second paragraph states that if lead does not exceed 13 µg/L during the two rounds of sampling planned then lead mobility will no longer be considered an issue for the Lower Subase. The Navy will have to conduct a more extensive investigation. Moreover, this approach would not satisfy the CT RSR and would require a waiver of this ARAR.

Response:

(a) Comment noted. Please see Response to GC2. The Navy believes that the extent of the Groundwater PDI as currently proposed is sufficient to address the identified data gaps. Additional groundwater sampling will be performed as part of the selected remedies.

(b) Disagree. The sentence indicates that if lead is not detected in groundwater at concentrations greater than 13 ug/L during both rounds of sampling, then no further investigation of groundwater to address the lead mobility issue is required. This sentence is meant to provide criteria to determine when the PDI sampling can be considered complete. As noted in the Responses to GC3 and GC7, an extensive Soil PDI is currently being planned, and collection of soil samples to address lead mobility concerns is a significant issue addressed in the Soil PDI SAP. Also, as noted in the Response to GC2 and previously discussed with the project team, groundwater monitoring will be a component of the remedies selected for the Lower Subase zones. Lead will likely be a contaminant of concern included in the groundwater monitoring programs. The results of the soil and groundwater PDIs will be used to determine the appropriate contaminants of concern.

SC5: p. 36, §11.5

The first sentence acknowledges that the scope of this proposed PDI is limited. Given the options available to the Navy to remediate this site, the PDI is not the place where Navy should withhold resources. EPA expects an appropriate investigation of the site groundwater to support the remedial decision for this site.

Response:

Comment noted. The Navy has invested significant resources into the investigation of the sites at the Lower Subase and development of appropriate remedial strategies. The current PDI is appropriately focused on addressing identified data gaps.

SC6: p. 38, Worksheet #13

The limitations of the existing data as discussed in this worksheet indicate that a more representative sampling program should be implemented to support accurate decision-making for this site.

Response:

Comment noted. See Responses to GC1 and GC2.

SC7: p. 40, Worksheet #14

a) Please supplement the partial sentence at the top of the page to include EPA in the distribution of well installation diagrams.

b) Regarding the second bullet under Monitoring Well Abandonment, does Navy intend to apply for a permit to abandon the wells?

Response:

(a) Disagree. The sentence is intended to clarify that the CTDEP would be notified that new wells were installed because they regulate well installation in the State of Connecticut. All field forms generated during the Groundwater PDI will be included in a Groundwater PDI Completion Report that will be submitted to the project team, including EPA.

(b) No. The Navy will meet the intent of the regulations during well abandonment activities and well abandonment forms will be prepared and included in the Groundwater PDI Completion Report to notify the CTDEP of the abandonments. This same process was followed during recent monitoring well abandonment activities completed by the Navy.

SC8: p. 41, Worksheet #14

a) The partial paragraph at the top of the page indicates that bedrock is shallow in Zone 5. If the water elevation is not at least fifteen feet greater than the bedrock elevation in Zone 5 then according to 22a-133k-2(c)(2)(E)(i), alternative pollutant mobility criteria (PMC) cannot be used. This was discussed in previous meetings. If necessary verify the bedrock and groundwater elevations during the PDI and if the CT RSR limitations are not satisfied, please revise the FS as necessary to comply with the requirements for alternative PMC. Provide the depth to bedrock for all seven zones.

b) The first full paragraph discusses the setting of the well screen elevations relative to the tide elevations. Because sampling will be conducted at low tide, the well screens need to be set at an elevation that will allow sampling to occur at low tide. In addition, the seasonal variation in water elevations needs to be considered because the plan is to sample at seasonal high water and seasonal low water. It may not be appropriate to set the screen so that the average tide elevation is within the screened interval or that the high tide not rise above the top of the screen. Please set the screen elevations accordingly.

Response:

(a) Geologic cross sections presented in the draft Groundwater PDI SAP and draft final Lower Subase FS were reviewed and it was determined that Zone 5 is the only zone where bedrock was encountered at a shallow depth. Based on the available geologic data presented on Figure 10-6

of the draft Groundwater PDI SAP (new Figure 10-7), bedrock is shallow only in the eastern portion of Zone 5. Bedrock slopes steeply towards the Thames River to the west, and the depth from the water table to the bedrock surface along the western boundary of the Zone 5 is approximately 28 feet. Because the depth of saturated overburden is greater than 15 feet along the western side of Zone 5 and the average thickness of saturated overburden is approximately 16.5 feet, adequate dilution will be available prior to leaving the site boundary. Therefore, alternative PMC are appropriate for use in Zone 5.

(b) Comment noted. To clarify this issue, the first sentence of the paragraph will be changed and a new second sentence will be added. The text will be changed to the following:

"The monitoring wells are located in an area that may be tidally influenced, so consideration should be given to the predicted tide heights and tidal range (daily, average, and seasonal fluctuations) for the area during drilling and installation activities in order to gauge the productivity of the new wells. The well screens will be set so that groundwater samples can be collected at low tide. The screens should be set so..."

SC9: p. 42, Worksheet #14

a) The vertical survey datum for the new wells is said to be the 1988 North American Vertical Datum (NAVD). This datum is different from the datum upon which the elevations for the existing wells is based. Please clarify if the 1988 NAVD datum will now be used for all wells and all vertical elevations going forward. It is not appropriate to maintain different datums for different wells. Please confirm that if NAVD 1998 is used for the new wells and conversions are developed for the existing wells to NAVD 1988 that the remedial design will also be based on NAVD 1988.

b) Under Monitoring Well Development, please supplement the text to require checking existing wells for any obstructions throughout the entire depth and to take measurements to confirm the bottom of the wells has been identified. Compare well depths to the installation logs for these wells for confirmation.

c) Under Groundwater Purging and Groundwater Sampling please edit the text to reference the new EPA Region 1 SOPs for low flow sampling and instrument calibration. Refer to the general comments for citations for these SOPs.

Response:

(a) All historic well information has been converted to the 1988 NAVD and this same datum will be used as the basis for the survey of all new wells and other future efforts. The boring logs included in Appendix B will be annotated to clarify the datum used to determine the elevations provided on the logs. In addition, a well location and construction table for all of the existing wells to be sampled will be prepared and included in Appendix B-2. The location coordinates

will be in Connecticut State Plane 1983 North American Datum (NAD) and the elevations will be in 1988 NAVD.

(b) Section 5.2 on p. 4 of 9 of Tetra Tech SOP GH-1.2, provided in Appendix A, specifically requires checking of existing wells for obstructions throughout the entire depth and to confirm the bottom of the wells are identified. References to the SOPs will be maintained to describe these routine field activities. A table that includes existing well construction details will be prepared and included in Appendix B-2 of the SAP. A reference to this table will be added to WS #14.

(c) Agree. The text will be edited to reference the new EPA Region 1 SOPs for low flow sampling and instrument calibration.

SC10: p. 55, Worksheet #21

Please replace the cited low flow groundwater sampling SOP with the Region 1 revised SOP "EQASOP-GW 001 Revision Number 3," dated January 19, 2010. I e-mailed this document to you recently.

Response:

Agree. The low flow groundwater sampling SOP referenced in Worksheet #21 will be replaced with the Region 1 revised SOP "EQASOP-GW 001 Revision Number 3," dated January 19, 2010.

SC11: p. 56, Worksheet #22

Please reference the Region 1 revised SOP "EQASOP-FieldCalibrat Revision Number 2" also dated January 19, 2010.

Response:

Agree. A reference to the Region 1 revised SOP "EQASOP-FieldCalibrat Revision Number 2", also dated January 19, 2010, will be added to Worksheet #21.

SC12: Table 10-1

The records provided for these wells indicates significant variability in the data. Generally this indicates the need for more data from these and other wells thought to be relatively uncontaminated. However, it could also indicate the need to analyze for a broader range of contaminants of concern than proposed in this SAP.

Response:

Comment noted. Please see Responses to GC1 and GC2.

SC13: Figures 11-1 to 11-4

These figures present the wells that will be sampled for the groundwater PDI. A more comprehensive groundwater sampling and investigation plan is expected based on the results of kriging conducted for the draft final FS and the limitations inherent in the existing groundwater and soil data. Further discussion of the scope of this PDI SAP is warranted. If Navy intends to address some of the concerns expressed in these comments during the soil PDI, that could resolve some of EPA's concerns.

Response:

Comment noted. Please see Responses to GC1 and GC2.

SC14: Worksheet #28

The acceptance limits in the Laboratory QC Samples Table included in this worksheet for the Lab Control Sample (LCS) and the Matrix Spike (MS) do not meet the 6020 method criteria, and are not the criteria listed in the lab's SOP (see also Appendix D, MET-6020, Sections 12.10 and 12.12 page 14 of 21, and the associated method QC table). Please correct.

Response:

The project laboratory was contacted about the comment. The laboratory confirmed that the limits provided in WS# 28 are consistent with their updated 2010 QC limits (see table below).

Method	Prep Method	Matrix	Analyte	LCS Accuracy (% Rec.)	Matrix Spike (% Rec.)	Precision (RPD)
6020	Red.Precip. (1640)	Seawater	Arsenic	71-124	50-147	20
6020	Red.Precip. (1640)	Seawater	Copper	63-128	50-120	20
6020	Red.Precip. (1640)	Seawater	Lead	82-113	55-118	20

The laboratory said that the QC limits in WS#28 and their SOP do not match because the laboratory does not routinely update the SOP to reflect the most recent QC limits. In addition, the laboratory said they are using Method 6020, not Method 6020A. While the specified QC limits do not meet the Method 6020 criteria, Method 6020 does not take into account the preparation method or the matrix; therefore, the laboratory's statistically-derived limits are appropriate. No changes are required in response to this comment.

Additional Comments Received via March 23, 2010 E-Mail

The following comments were generated as a summary of EPA's concerns with the Groundwater PDI scope.

Zone 1:

1. Potential presence of free product (virgin and waste oil) west and under Building 29 and southwest and south of Building 29. Free product was formerly identified at 13MW5 and 13MW18; TPH exceeded Navy free-product threshold of 22,500 milligrams per kilogram (mg/Kg) at GS-32L and 13MW18; TPH also exceeded the 7,500 mg/Kg threshold at 13MW2, 13MW3, and GS-29L.

2. Additional groundwater investigation is required west of Building 29 owing to characterization of free product plume extending from 13MW18 west under Building 29.

3. Mobilization of metals is expected at and downgradient of areas impacted by free product and petroleum releases. The proposed sampling plan does not address this.

Zone 2:

Potentially mobile lead was detected at 13MW11: TCLP lead was 8,600 µg/L potentially impacting groundwater. No sampling is proposed to evaluate this.

Zone 3:

1. Extensive elevated lead concentrations in soil in excess of the industrial/commercial threshold create potential mobility concerns for groundwater contamination. No sampling is proposed to evaluate this.

2. Lead was detected at GW-02 at 392 µg/L (unfiltered).

3. Zone 3 was formerly used to overhaul batteries.

Zone 4:

1. Elevated lead concentrations in soil above the industrial/commercial threshold create potential mobility concerns for groundwater contamination. No sampling is proposed to evaluate lead in groundwater.

2. Proposed SAP fails to include sampling in the northwestern corner of Zone 4 where significant lead contamination has been detected. Boring 13TB3A had a lead TCLP of 150 mg/L. Also boring WE4A, centrally located in Zone 4, had a lead TCLP of 143 mg/L.

3. Free product was detected in Zone 4 along the river front and at well NESO-9 where from 1 to 5 feet of product was present in this well. A product recovery system was operated in Zone 4 but was abandoned as ineffective. A well should be installed at NESO-9 and sampled for metals, organics, and NAPL.

4. Petroleum contamination in Zone 4 will facilitate the mobilization of metals.

5. 13MW15 could not be found according to the 2007 Well Inventory report. Therefore, it cannot be sampled and the PDI does not indicate that it will be replaced. Please reconcile.

Zone 5:

Zone 5 was formerly used for management of battery acid, including transfer lines and storage tanks. No sampling of groundwater is proposed for lead.

Zone 7:

1. Extensive elevated lead concentrations in soil in excess of the industrial/commercial threshold create potential mobility concerns for groundwater contamination. No groundwater sampling is proposed to assess for lead in groundwater.

2. Petroleum contamination in Zone 7 will facilitate the mobilization of metals.

3. Wells MW2-7RI, MW3-7RI, MW4-7RI, 20MW2, 20MW3, and 20MW6 should be sampled for lead and arsenic.

4. 20MW7 could not be found according to the 2007 Well Inventory report; therefore, it cannot be sampled and the PDI does not indicate that it will be replaced. Please correct.

Response:

The draft Soil PDI Work Plan was submitted to the EPA on March 19, 2010. The Work Plan includes an extensive soil sampling program.
Per discussions conducted during the March 24, 2010 Production Meeting, the Navy and EPA agreed that additional data collection may be required post-ROD to address remaining data gaps. The details of any additional sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

Two additional monitoring wells were identified by EPA as not being located in the 2007 Monitoring Well Inventory; 13MW15 and 20MW7. Additional efforts will be conducted to locate these wells, but if they are not found, the two wells will be re-installed and designated as MW1-4PDI and MW1-7PDI, respectively. The new wells will be located in the same locations, and screened over the same depths, as the original two wells.

Rich, Corey

From: Keckler.Kymberlee@epamail.epa.gov
Sent: Friday, April 09, 2010 5:28 PM
To: james.gravette@navy.mil; richard.conant@navy.mil; Rich, Corey; mark.lewis@po.state.ct.us; rtfinlayson@gfnet.com; gkemp@gfnet.com; DiMattei.Steve@epamail.epa.gov
Subject: Responses to EPA's Rebuttal Comments on the Sampling and Analysis Plan UFP-SAP for Pre-Design Groundwater Sampling at Lower Subase
Attachments: Edited Lower Subase GW UFP-SAP.doc

EPA reviewed the responses, dated March 31, 2010, to EPA's March 23, 2010 comments on the Sampling and Analysis Plan UFP-SAP for Pre-Design Groundwater Sampling at Lower Subase for the Naval Submarine Base dated January 2010. This document presents the sampling plan and rationale for additional groundwater sampling of the Lower Subase in support of the decision document and the remedial design.

General Comments #1, #2, #3, #6, #7, #9: During the March 24, 2010 conference call, EPA expressed a preference for a more comprehensive initial GW PDI than the one proposed. As a compromise, the team agreed that a follow up GW PDI would be conducted for the RD, the scope of which would be determined based on the results of the planned initial PDI. The option of relying solely on the groundwater monitoring program to collect post-ROD groundwater data was eliminated. Please ensure this agreement is clarified in the call minutes and project records. Thank you.

I am enclosing an edited version of the SAP for your approval. EPA made the edits using redline-strikeout to the following sections (minor editorial notes are not listed below):
p. 32; Sec 10.2
p. 37; Sec 11.6
pp. 41 & 42 Monitoring well abandonment

I believe these changes are in-line with our discussions. EPA will sign this version if you agree. I will be in the office all of next week if you'd like to discuss this. Thank you.

Have a nice weekend,
Kymberlee

(See attached file: Edited Lower Subase GW UFP-SAP.doc)

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RESPONSES TO CTDEP MARCH 2, 2010 COMMENTS
AND MARCH 30, 2010 REBUTTALS
DRAFT SAMPLING AND ANALYSIS PLAN
UFP-SAP FOR PRE-DESIGN GROUNDWATER SAMPLING AT LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

INITIAL ISSUE: March 9, 2010
REVISION 1 ISSUE: April 14, 2010

GENERAL COMMENTS

General Comment (GC) 1:

The PDI focuses solely on metals. DEP acknowledges that the PDI is only a part of the overall groundwater investigation. However petroleum hydrocarbons and PAHs are also present in Lower Base soil and groundwater. It would be prudent to include these contaminants in the PDI. This would provide a more complete data set to support remedial decisions for soil and groundwater. The nature and extent of all groundwater contaminants must be fully delineated.

Response:

Disagree. TPH was identified as a groundwater contaminant of concern based on the current data set. It is believed that the current data set is sufficient to select remedies. The preferred remedies for soil and groundwater will include groundwater monitoring; therefore, additional sampling is not needed for remedy selection or remedial design.

PAHs were not identified as groundwater contaminants of concern in the draft final Lower Sub Base Feasibility Study; therefore, further sampling for them is not warranted.

No changes to the text of the Groundwater Sampling and Analysis Plan are required in response to this comment.

DEP Rebuttal:

The Navy discussed this issue with EPA and DEP during a conference call on March 23, 2010. During that call, the Navy stated that it would prefer to go ahead with the pre- design investigation as planned. The Navy suggested that the concerns expressed by EPA and DEP regarding the extent of TPH contamination be handled through groundwater monitoring as part of a remedy, and that the PDI proceed as planned. EPA suggested that the ROD include language noting that the planned soil and groundwater investigations may identify potential issues that require the groundwater monitoring program to be amended.

As I noted during the March 23, 2010 conference call, this approach is acceptable to DEP, with the understanding that additional data gaps may be identified by the soil investigation or by either of the two rounds of groundwater investigation under the PDI. During the March 23, 2010 conference call, the Navy stated that the ROD will capture the need for any additional

evaluation and monitoring. Please note that this could require the installation of additional monitoring wells, or other actions to address identified data gaps. Given the possibility of data gaps, and the fact that most of the existing groundwater data is more than 10 years old, it is possible that post ROD monitoring will need to be more rigorous than would otherwise be the case.

Response to Rebuttal:

The Navy agrees that additional groundwater data collection may be required post-ROD to address remaining data gaps as part of another groundwater PDI or as part of the groundwater monitoring programs that will be implemented as part of the groundwater remedies. The details of any additional groundwater sampling programs will be resolved after the results of the currently proposed groundwater and soil PDIs are available and evaluated.

SPECIFIC COMMENTS

Specific Comment (SC) 1: SAP Work Sheet # 9- Project Scoping Participants Sheet

The telephone number for Rosemary Gatter- Evarts is (860) 424-3732. The phone number for Bill Warzecha is (860) 424-3776. My e- mail address is now mark.lewis@ct.gov. Please revise the table.

Response:

Agree. The requested changes will be made to WS #9.

DEP Rebuttal:

Response accepted. No further revisions required.

Response to Rebuttal:

Agree.

SC2: Section 10.1.3 Thames River Page 31

The third paragraph notes that the surface water quality classification of the Thames River is SC/SB. Please note that the surface water quality standards are being revised. Waters presently classified as SC/SB will no longer be classified as SB. This will have no effect on the DEP's approach to the Sub Base since the goal for waters currently classified as SC/SB is to restore them to class SB. Please note this for any future documents.

Response:

Comment noted. The Section 10.1.3 text on p. 31 will be updated to note that CTDEP is revising the surface water quality standards. No other changes are anticipated.

DEP Rebuttal:

Response accepted. DEP's comments should have said that areas currently classified as SC/SB will now be classified as SB. DEP apologizes for any confusion caused by this error.

Response to Rebuttal:

Agree.

SC3: Section 10.1.2.4 Zone 7 Page 31

The text notes that elevated arsenic concentrations in wells 20MW7 and MW4-7RI are likely not due to matrix interference, but these wells are likely not fully representative of groundwater conditions at the point of discharge to the river. Since these two wells are the closest of the monitoring wells in Zone 7 to the river, DEP assumes that they are representative of conditions at the discharge point unless additional wells are installed further downgradient from these two wells.

Response:

Comment noted. The subject text was meant to clarify that although these wells are the most down gradient at Zone 7, they are still 70 to 90 feet from the Thames River and additional mixing and dilution may occur prior to the groundwater discharging to the Thames River. The two monitoring wells (20MW7 and MW4-7RI) in question are included in the proposed Groundwater PDI and two rounds of additional data will be collected from these wells to assess arsenic concerns. No text changes are required in response to this comment.

DEP Rebuttal:

Response accepted. No further revisions required.

Response to Rebuttal:

Agree.

SC4: Section 10.2 Conceptual Site Model Page 32

The second paragraph refers to protecting construction workers from groundwater exceeding "direct exposure criteria for groundwater", as well as protecting ecological receptors. The following paragraph adequately discusses the surface water protection criteria, but the text provides no clarification regarding the "direct exposure criteria" for groundwater.

Please clarify that the RSR criteria applicable to groundwater in a GB area are the surface-water protection criteria and volatilization criteria. Those criteria are based on protection of human health from exposure through ingestion of water or inhalation of unacceptable levels of chemicals that may be off gassing from polluted ground water into overlying buildings and ecological receptors and aquatic organisms.

Response:

Agree. The following sentence will be added to the end of the second paragraph:

"The Navy intends to manage any direct exposure risks to groundwater by managing contact with groundwater through land use controls and requiring the use of personal protective equipment if there is a need to be in contact with groundwater. Collection of additional groundwater data is not required to evaluate direct contact concerns."

The following sentences will be added to the second paragraph as the second through fourth sentences:

"For the contaminants of concern (metals), CTDEP RSRs identify human health direct exposure criteria and surface water protection criteria (SWPC) as the applicable criteria for GB-classified groundwater. Volatilization Criteria are not applicable for metals because they do not volatilize from groundwater. The direct exposure criteria consider dermal contact as the primary exposure pathway and the SWPC are based on protection of human and ecological receptors from exposure through ingestion of water and organisms."

DEP Rebuttal:

The language the Navy proposes to add to the end of the second paragraph is acceptable. The language proposed for addition as the second through fourth paragraphs should be revised to reflect the fact that the RSRs do not provide specific numerical criteria for the human health risk posed by direct contact with contaminated groundwater. However, DEP agrees that it is appropriate to address these risks. DEP would likely do so using its authority pursuant to section 22a-133k-3(i) of the RSRs to require additional remediation of groundwater to address "... any threat to human health or the environment.." DEP suggests the following language in place of that proposed by the Navy for the second through fourth paragraphs: "For the contaminants of

concern (metals), CTDEP RSRs identify surface water protection criteria (SWPC) as the applicable criteria for GB-classified groundwater. *The RSRs do not include numerical criteria to address the human health risk posed by direct contact with groundwater contaminants. However, the RSRs require that where groundwater contaminants pose a direct contact risk to human health, additional action must be taken to address that risk.* Volatilization Criteria are not applicable for metals because they do not volatilize from groundwater. The direct exposure criteria consider dermal contact as the primary exposure pathway and the SWPC are *ground water criteria* based on protection of human and ecological receptors from exposure through ingestion of water and organisms."

Response to Rebuttal:

Agree. As suggested by CTDEP, the following sentences will replace the second through fourth sentences in the second paragraph of Section 10.2 - Conceptual Site Model (Page 32):

"For the contaminants of concern (metals), CTDEP RSRs identify surface water protection criteria (SWPC) as the applicable criteria for GB-classified groundwater. The RSRs do not include numerical criteria to address the human health risk posed by direct contact with groundwater contaminants. However, the RSRs require that where groundwater contaminants pose a direct contact risk to human health, additional action must be taken to address that risk. Volatilization Criteria are not applicable for metals because they do not volatilize from groundwater. The direct exposure criteria consider dermal contact as the primary exposure pathway and the SWPC are *ground water criteria* based on protection of human and ecological receptors from exposure through ingestion of water and organisms."

SC5: Section 11.2 Information Inputs Page 33

Please correct the reference to the DEP protocol for analysis of trace metals. The proper title is "State of Connecticut, Department of Environmental Protection, Recommended Reasonable Confidence Protocol Quality Assurance and Quality Control Requirements, Determination of Trace Metals by SW-846, Method 6020, Inductively Coupled Plasma- Mass Spectrometry, Version 2.0, July 2006".

Response:

Agree. The reference will be corrected as requested.

DEP Rebuttal:

Response accepted. No further revisions required.

Response to Rebuttal:

Agree.

SC6: Section 11.3 Study Boundaries Page 35

The samples will be collected around the time of low tide. DEP agrees that this is appropriate. Please specify how long before and after the low tide sampling will be conducted.

Response:

The level of detail requested is not appropriate for WS #11, but is appropriate for WS #14. On p. 42 of the SAP (WS #14), under Groundwater Purging, it indicates that purging of tidally influenced wells will begin approximately 2 hours before the predicted low tide. Depending on the results of purging, sampling will typically be conducted within a 2-hour window bracketing the time of the predicted low-tide (i.e., sampling can begin approximately 1 hour prior to and 1 hour after low tide). The previous sentence will be incorporated into the Groundwater Sampling section of WS #14 on p. 43 of the SAP.

DEP Rebuttal:

Response accepted. No further revisions required.

Response to Rebuttal:

Agree.

SC7: Section 11.4 Analytic Approach Page 40

The text states that if lead is not detected in groundwater in any zone at a concentration greater than 13 µg/l during two rounds of groundwater sampling, then, no further investigation of groundwater to address lead mobility will be conducted. The text implies that in this case, no further soil investigation will be conducted. Please note that DEP expects that the extent of soil exceeding the pollutant mobility criteria will be fully delineated, regardless of the results of groundwater monitoring.

Response:

The sentence indicates that if lead is not detected in groundwater at concentrations greater than 13 ug/L during both rounds of sampling, then no further investigation of <u>groundwater</u> to address the lead mobility issue is required. This sentence is meant to provide criteria to determine when the PDI sampling can be considered complete. An extensive Soil PDI is currently being planned, and collection of soil samples to address lead mobility concerns is a significant issue addressed in the Soil PDI SAP. As previously discussed with the project team,

groundwater monitoring will be a component of the remedies selected for the Lower Subase zones. Lead will likely be a contaminant of concern included in the groundwater monitoring programs. The results of the soil and groundwater PDIs will be used to determine the appropriate contaminants of concern. No changes to the text of the Groundwater Sampling and Analysis Plan are required in response to this comment.

DEP Rebuttal:

Response accepted. No further revisions required. DEP understands that groundwater monitoring will be a part of the remedies selected for the Lower Base. DEP expects that lead will be one of the parameters included in post remediation groundwater monitoring, based on its presence in soil.

Response to Rebuttal:

Agree.

SC8: Worksheet 14 Page 40

The text states that a permit for well abandonment must be obtained from the State Plumbing and Piping Work Examining Board. Please correct this statement to say that the permit must be obtained from the Ledgelight Health District.

Response:

Agree with clarification. Subsection §25-128-61(a) of Title 25, Section 128 of Regulations of Connecticut State Agencies indicates that you should apply to the Board (defined as State Plumbing and Piping Work Examining Board) for the permit and Subsection §25-128-61(b) indicates that the completed permit application should be submitted to the local director of health. Considering the regulation, the subject text will be updated as follows:

"Prior to abandoning any wells, a registered well contractor must apply to the State Plumbing and Piping Work Examining Board for a permit and submit the completed permit application to the Ledgelight Health District for approval."

In addition, the following text will be added after the abandonment procedures:

"However, because this work is being conducted under CERCLA, the Navy does not intend to formally apply for the well abandonment permits, but will meet the intent of the regulations during abandonment activities. This process has been used during previous well abandonment activities at NSB-NLON. All abandonment logs will subsequently be provided to the CTDEP as part of the Groundwater PDI Completion Report."

DEP Rebuttal:

Response accepted. No further revisions required.

Response to Rebuttal:

Agree.

SC9: SAP Worksheet 14 Page 40

In the second full paragraph, please specify the vertical extent of coring that will be completed in boring MW1-5PDI.

Response:

To clarify, the text in question is provided on p. 41 of the SAP. The text is incorrect and no bedrock coring is proposed for this project. The second and third sentences in the second full paragraph on p. 41 of the SAP will be deleted.

DEP Rebuttal:

Response accepted, and Navy clarification acknowledged. No further revisions required.

Response to Rebuttal:

Agree.

SC10: SAP Worksheet 14 Page 41

This section notes that well 19MW4, located in Zone 5 was only installed to a depth of 5.75 feet due to shallow bedrock. The Navy has calculated pollutant mobility criteria for metals in this and other zones using a site specific dilution factor pursuant to section 22a-133k-2(c)(2)(E)(i) of the Remediation Standard Regulations. This section specifies that an alternative dilution factor may only be used if, among other things, the water table in the release area is at least fifteen feet above the surface of bedrock. This is because if the water table is less than 15 feet above the bedrock surface, there will not be sufficient dilution of water flowing through the vadose zone before it reaches the water table. Please check the depth to bedrock in other zones to ensure that a sufficient depth to bedrock is present.

Response:

Geologic cross sections presented in the draft Groundwater PDI SAP and draft final Lower Subase FS were reviewed and it was determined that Zone 5 is the only zone where bedrock was

encountered at a shallow depth. Based on the available geologic data presented on Figure 10-6 of the draft Groundwater PDI SAP (new Figure 10-7), bedrock is shallow only in the eastern portion of Zone 5. Bedrock slopes steeply towards the Thames River to the west, and the depth from the water table to the bedrock surface along the western boundary of the Zone 5 is approximately 28 feet. Because the depth of saturated overburden is greater than 15 feet along the western side of Zone 5 and the average thickness of saturated overburden is approximately 16.5 feet, adequate dilution will be available prior to leaving the site boundary. Therefore, alternative PMC are appropriate for use in Zone 5.

DEP Rebuttal:

Response accepted. DEP agrees that alternative PMCs may be used in Zone 5. Please revise the text to document the results of this analysis.

Response to Rebuttal:

Agree with clarification. No changes to the SAP are required to address this comment. The current Alternative PMCs developed and used in the Lower Subase Feasibility Study will be retained.

APPENDIX F

TITLE 25, SECTION 128 OF REGULATIONS OF CONNECTICUT STATE AGENCIES

NOTE: This is an unofficial copy of the subject regulations. Please check with the appropriate agency for an official up to date version.

REGULATIONS OF CONNECTICUT STATE AGENCIES
TITLE 25. WATER RESOURCES
DEPARTMENT OF CONSUMER PROTECTION
DESCRIPTION OF ORGANIZATION, RULES OF PRACTICE, AND REGULATIONS FOR THE WELL DRILLING INDUSTRY

The Connecticut Regulations titles are current with material published in the Connecticut Law Journal through 12/27/05.

§ 25-128-33. Title of regulations

These regulations, together with the regulatory provisions of Chapter 482 of the General Statutes, and the section of the Public Health Code relating to wells, shall be collectively known as the Connecticut Well Drilling Code.

(Effective September 27, 1978.)

§ 25-128-34. Purpose of regulations

The purpose of the regulations shall be to govern the construction, repair, development, and abandonment of wells, in order to safeguard the public health and to provide an adequate supply of clean and uncontaminated water for all persons in the state of Connecticut.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-35. Scope of regulations

(a) Well Contractors and Drillers. The regulations shall apply to any person who engages in the industry, procedures, or operation, full time or parttime, for compensation or otherwise, of obtaining water from a well or wells by drilling, or other methods. A well drilling contractor is any person regularly offering to the general public the services of his employees or himself in the industry of obtaining water from a well for any purpose or use.
(b) Abandoned wells. The regulations shall apply to any person who abandons and permanently discontinues the use of a well, or to any person who is responsible by law for the abandonment of a well except as provided by Section 25-134 of the General Statutes.
(c) Special exception for farmers. The regulations shall not require a person who

an accepted chlorine solution or other accepted disinfection material or procedure.
(11) Drawdown: The extent of lowering of the water table or piezometric surface within or adjacent to the well, resulting from the discharge of water from the well. Draw down is measured between the static water level and the pumping water level. The quantity of water available in the well from the static water level to the pump intake is known as the draw down available.
(12) Established ground surface: The permanent elevation of the surface of the ground at the site of the well after completion of grading, excavation; or other land movements.
(13) Ground water: Water encountered below the ground surface of the earth within the zone of saturation that can supply wells and springs.
(14) Grout or grouting material: A low permeability material placed in the annular space between the casing and the formation or within the borehole which is at least as impermeable as the soil formation. The purpose of the grout is to resist the migration of pollutants into the annular space.
(15) Cement grouts: A mixture of portland cement, sand, and water. The mixture is usually composed of one bag of portland cement weighing ninety-four (94) pounds, an equal volume of dry sand, and five to six gallons of water.
(A) Neat cement grout: A mixture of not more than six gallons of clear water to one bag of portland cement.
(B) Sand cement grout: A mixture of not more than two parts sand to one part portland cement, and not more than six gallons of clear water to each bag of cement.
(C) Concrete grout: A mixture of portland cement, sand, gravel and water.
(D) Bentonite grout: mined processed bentonite clay.
(E) Bentonite cement grout: A mixture of cement grout or sand cement grout with approximately ten per cent (10%) bentonite added to reduce shrinkage.
(F) Natural grout: A mixture of water and natural materials excavated during drilling of the well. The materials shall be placed by whatever techniques are effective for the existing conditions to achieve maximum density, strength, and impermeability of the fill material.
(G) Sand clay grout: A mixture of bentonite clay and sand in equal proportions.
(16) Flowing artesian well: A well in which the static water level is higher than the top of the casing and water flows from the well.
(17) Installation of pumps and pumping equipment: The procedure employed in the placement and preparation for operation of pumps and pumping equipment, including all construction involved in making entrances to the well and to the building, establishing seals, installing pump piping, valves, wiring, electrical controls and tanks.
(18) Liner pipe: Pipe that is installed inside a completed and cased well for the purpose of sealing off undesirable water or for repairing ruptured or punctured casing or screens. The liner pipe and screens may be constructed of PVC schedule forty (40) plastic.
(19) Owner: Any person or his agent who holds the title or other rights of property where a well is constructed, repaired, or abandoned.
(20) Potable water: Water free from impurities in amounts sufficient to cause disease or other harmful physiological effects, with the minimum or maximum bacteriological, physical, and chemical composition as defined by the applicable laws and regulations of the Department of Health Services.
(21) Repair: Any work involved in the reaming, sealing, installing, changing of casing

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-37. Manner of construction

The construction of any well shall be planned and carried out in a manner to guard against waste and contamination of ground water resources.

(Effective September 27, 1978.)

§ 25-128-38. Application of public health code

The regulations for the construction of wells, as provided herein, shall be construed in a manner consistent with the provisions of Sections 19-13-B51 to 19-13-B51m, inclusive, of the Public Health Code. In the event any conflict shall appear, the interpretation of the regulations shall be made which affords the greater protection of the public health.

(Effective September 27, 1978.)

§ 25-128-39. Adequate relations of diameter, depth, and yield

Wells shall be of adequate diameter and depth to be capable of yielding the quantity of water required by the user. For the use of an individual household, a bedrock well of six (6) inches in diameter shall be satisfactory when it is capable of yielding:
(a) five (5) gallons per minute and has a storage available of seventy-five (75) gallons or has a water column depth of one hundred (100) feet, whichever is greater;
(b) three and one half (3 1/2) gallons per minute and has a storage available of one hundred fifty (150) gallons or has a water column depth of one hundred fifty (150) feet, whichever is greater;
(c) two gallons (2) per minute and has a storage available of two hundred twenty-five (225) gallons or has a water column depth of two hundred (200) feet, whichever is greater;
(d) one gallon per minute and has a storage available of four hundred (400) gallons or has a water column depth of three hundred seventy-five (375) feet, whichever is greater;
(e) one half (1/2) gallon per minute and has a water column depth of four hundred fifty (450) feet or has a storage available of six hundred (600) gallons, whichever is greater.
(f) storage may be provided using combinations of hydropneumatic tanks and/or non-pressurized tanks with booster pumps.
(g) wells yielding less than one half (1/2) gallons per minute shall be pump tested for at least eighteen hours (18) to prove the well yield. It is not recommended that a well with less than one half (1/2) gallon be used as the only supply for an individual household.
In the event, however, that in the opinion of the Board, special or unusual geological, hydrological, or other circumstances shall exist in the construction of any well, the Board may determine the minimum requirements of diameter, depth, and yield for the well.

fittings in any public or private potable water supply system or any water user's pipelines.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-43. Casing of drilled wells

(a) The bottom end of the primary casing shall be equipped with a hardened drive shoe of the appropriate size.
(b) The casing shall extend at least six (6) inches above the land surface. Annular space shall be grout filled from the frost level to the bottom of the casing, except that, where special or unusual conditions exist, the annular space shall be grout filled from the frost level to a distance of at least ten (10) feet below the land surface.
(c) Upon completion of the well unit and until such time as the well is equipped with a pump, the top of the casing shall be a metal cap fixed to prevent unwarranted access.
(d) The primary casing shall be new steel and shall be free of pits, breaks, or other serious imperfections. All casing pipes and couplings used shall have minimum weights and wall thicknesses per diameter, as specified in Table 1.
(e) In the event casing pipes are assembled together, they shall be joined by means of watertight welded joints, screw coupling joints, or slip joints. In the use of welded joints, the weld shall be at least as thick as the wall thickness of the well casing.
(f) In the event the diameter of a casing is reduced at any point along its length, the annular space between the larger and smaller casings shall be made watertight.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-44. Length of casing, drilled wells

A twenty (20) foot minimum length of casing pipe shall be required in the construction of any drilled well, subject to the following exceptions for specific, geological and hydrological conditions:
(a) All unconsolidated overburden and other loose, caving zones shall be cased.
(b) The casing pipe shall extend at least five (5) feet into the bedrock, as shown by Figure 1.
(c) In the event, however, that the overburden or the upper five (5) feet of the bedrock constitute the primary potable water producing zones, the requirement of length of subsection (b) shall not apply.
(d) In the condition of the presence of caving zones, the casing pipe or other adequate protective seal shall extend as great a distance below the caving zone as the driller deems necessary to insure well stability.
(e) In the event geological conditions require telescoping of the casing pipe and the use of linear pipe, the respective lengths and diameters necessary to accomplish effective drilling shall be used, the annular spaces shall be made watertight where appropriate to prevent the travel of contaminants.

(d) Any well constructed with multiple screens shall not connect aquifers or zones which have differences in water quality, classification or which maintain different piezometric surfaces.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-47. Gravel packed wells, gravel

(a) The gravel in a gravel packed well shall be composed of material that does not react chemically with the water in the well, and will not create or enhance encrustation or corrosion.
(b) The gravel shall be clean, rounded, uniform, water-washed, and free from clay, silt, or other deleterious substance.
(c) The size of the gravel shall be as determined by a grain size analysis of the formation material.
(d) The gravel shall be disinfected by adding sufficient chlorine to the placement fluid to produce a chlorine residual of approximately one hundred parts per million (100 ppm).
(e) The gravel shall be placed in such a manner that no bridging or layering occurs.
(f) The gravel pack shall not connect aquifers or zones which have differences in water quality classification or in static water levels.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-48. Gravel packed wells, construction

In a gravel packed well in which the top of the gravel does not extend inside the outer casing, a cement group plug of at least five (5) feet in thickness shall be placed in the annular space directly on top of the gravel. The remaining space shall be filled with grout except that the upper ten (10) feet below the frost level shall be filled with cement grout. Centering guides shall be attached to pipe extensions about the well screen and to blank pipes separating different screened sections. The gravel filled pipes shall be properly capped.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-48a. Annular space

(a) Any annular space between the outside of the casing and the natural materials penetrated by the well shall be filled with suitable material to make this space as impervious to the movement of fluids and competent to support the casing as are the natural materials surrounding the well. The driller may fill the annular space with the natural materials excavated during the drilling of the well to meet the following requirements:

method, the air rotary drill method, or the air lift method. For wells serving a single family the well may be tested for yield by removing as much water as is practicable from the well and measuring the rate of recovery.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-52. Disinfection of wells

All wells shall be disinfected by chlorination as provided by Section 19-13-B 51 K(c) of the Public Health Code.

(Effective September 27, 1978.)

§ 25-128-53. Construction of non-water supply wells

All wells used for other purposes than the supply of water for human consumption shall be constructed, repaired, and maintained in such a manner that they are not a source or cause of ground water contamination.

(Effective September 27, 1978.)

§ 25-128-54. Maintenance and repair of wells and pumping equipment

All wells shall be maintained in a proper condition to conserve and protect ground water resources, and shall not be a source or cause of contamination or pollution of the water supply of any aquifer. All materials and construction practices used in the maintenance, repair, or replacement of any well shall be the same as those required for the construction of a new well. All maintenance, repair, hydrofracturing, developing, and replacement work shall be done only by a registered well driller, or by a licensed plumber or electrician, as provided by Section 25-129 of the General Statutes, and Articles 5 and 6 of the regulations.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-55. Promulgation of construction standards

The regulations for the construction, maintenance, and repair of wells, as provided herein shall be promulgated in cooperation with the State Department of Health Services and the Department of Environmental Protection.

(Effective September 27, 1978.)

dilution of the grout.
(g) Any well constructed in a consolidated rock formation, may be filled with fine sand in the zone or zones of consolidated rock. The top of the sand fill shall be at least ten (10) feet below the bottom of the casing, and the remaining portions of the well shall be filled with any of the materials specified in subsection (e).
(h) Any test well or bore shall be abandoned in such a manner that it does not become a channel for the vertical movement of water or other substance to the potable ground water resources.
(i) Deep waste disposal or oil wells with casings free of any breaks, and extending below the potable ground water zones, may be sealed with a watertight cap or welded plate.
(j) Upon completion of abandonment of the well, the top of the casing or grout material may be terminated at least four (4) feet below the ground surface.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-58. [Repealed.]

(Repealed May 21, 1993.)

Sec. 25-128-58a. Contractor-limited to well water-supply drilling W-1

As provided by Section 25-129 of the General Statutes, the Board hereby establishes certain requirements for the registration of well drilling contractors. This registration permits the registrant to construct a well, including but not limited to, the installation, repair and maintenance of pumps, pump motors, pump piping, valves, wiring, electric controls and tanks. Before any registration is issued to any individual the Board shall require that the applicant submit:
(1) His full, legal name, street address, city, state and zip code;
(2) A certificate of liability insurance specifying well drilling purposes and providing liability coverage for bodily injury of at least one hundred thousand dollars ($100,000) per person with an aggregate of at least three hundred thousand dollars ($300,000), and for property damage of at least fifty thousand dollars ($50,000) per accident with an aggregate of at least one hundred thousand dollars ($100,000);
(3) Documentation that he has been actively engaged in the well drilling trade as a well driller for a period of thirty-six (36) months prior to the date of his application and/or has held a valid W-2 registration for at least two years;
(4) The name(s) and address(es) of his employee(s) who holds a master driller registration;
(5) Letters of references from a Connecticut registered well contractor, a local public health official and one (1) other responsible citizen which attest to the applicant's integrity and ability to act as a well driller; and
(6) He shall be found in compliance with all provisions of subsection (e) (1) of section 25-129 of the General Statutes, concerning his conduct in the well drilling industry.

the registrant is in the direct and regular employment of a contractor registered for such work. The applicant shall demonstrate his knowledge of well drilling by passing a written examination conducted pursuant to Sections 21a-7 (1) and 21a-8 (5) of the General Statutes.

(Effective May 21, 1993.)

§ 25-128-60b. Well driller - limited to well non-water-supply drilling W-4.

The requirements for this registration shall be three (3) years as an apprentice driller or possess equivalent experience and training. This registration permits the registrant to construct a well, including but not limited to, the installation, repair and maintenance of pumps, pump motors, pump piping, valves, wiring, electric controls and tanks only while the registrant is in the direct and regular employment of a contractor registered for such work. The applicant shall demonstrate his knowledge of well drilling by passing a written examination conducted pursuant to Sections 21a-7 (1) and 21a-8 (5) of the General Statutes.

(Effective May 21, 1993.)

§ 25-128-61. Permit requirement

(a) Before commencing work on the construction, repair, development, hydrofracturing or abandonment of any well, a registered well contractor shall apply to the Board for a permit, as provided by Section 25-130 of the General Statutes. The applicant shall be required to agree by his signed, written oath that all work under the permit shall be done in strict compliance with the Connecticut Well Drilling Code, unless a special exemption from one or more of the regulations of the Board has been granted.
(b) The contractor shall then submit the completed, signed permit application with the proper fee to the local director of health or his agent who shall approve such permit if said proposed well conforms to the public health code. No well shall be drilled until such a permit has been issued and approved.
(c) Water supply well permits shall be evaluated according to their content with regard to proper separating distances as outlined in the public health code.

(Effective September 27, 1978; Amended May 21, 1993.)

§ 25-128-62. Contents of permit application

The application for a permit by a registered well driller shall include an appropriate map or plot plan, showing the location of the proposed well and the premises on which the well is located, in relation to roads, intersections, and other permanent land features. All permit applications shall be signed by a master driller, as representative of the registered well-drilling contractor.

(Effective September 27, 1978.)

(Effective June 28, 2004.)

§ 25-129-2. Journeyperson-limited to well casing extension W-6

The requirements for the registration of a journeyperson-limited to well casing extension W-6 shall be a journeyperson's license to perform plumbing and piping work pursuant to chapter 393 of the Connecticut General Statutes. This registration permits the registrant to perform well casing extension, repair and maintenance work only while in the employ of a contractor licensed for such work. The applicant shall demonstrate knowledge of well casing extension, repair and maintenance work by passing a written examination conducted pursuant to section 20-333 of the Connecticut General Statutes.

(Effective June 28, 2004.)