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SAMPLING AND ANALYSIS PLAN FOR GROUNDWATER PLUME EVALUATION SITE 4
GOLF COURSE LANDFILL NCBC GULFPORT MS
4/1/2012
TETRA TECH

Comprehensive Long-term Environmental Action Navy

CONTRACT NUMBER N62470-08-D-1001



Rev. 1
04/24/12

Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan)

Groundwater Plume Evaluation Site 4 – Golf Course Landfill

Naval Construction Battalion Center Gulfport
Gulfport, Mississippi

Contract Task Order JM48

April 2012



NAS Jacksonville
Jacksonville, Florida 32212-0030



TETRA TECH

Document Tracking Number 12JAX0097

April 24, 2012

Project Number 112G03334

Commanding Officer, Southeast
Naval Facilities Engineering Command
Attn: Charles Cook (Code OPA6)
Remedial Project Manager
NAS Jacksonville
135 Ajax Street
Jacksonville, Florida 32212-0030

Reference: CLEAN Contract Number N62470-08-D-1001
Contract Task Order Number JM48

Subject: Final Sampling and Analysis Plan (Field Sampling Plan and quality Assurance Project Plan) for Groundwater Plume Evaluation at Site 4, Golf Course Landfill, Naval Construction Battalion Center Gulfport, Mississippi

Dear Mr. Cook:

Tetra Tech is pleased to submit the Final Sampling and Analysis Plan (Field Sampling Plan and quality Assurance Project Plan) for Groundwater Plume Evaluation at Site 4, Golf Course Landfill, Naval Construction Battalion Center (NCBC) Gulfport, Mississippi that was prepared for the United States Navy, Naval Facilities Engineering Command Southeast under Contract Task Order (CTO) JM48 for the Comprehensive Long-term Environmental Action Navy (CLEAN) Contract Number N62470-08-D-1001.

If you have any questions with regard to this submittal, please do not hesitate to contact me by telephone at (904) 730-4669, extension 215, or via e-mail at Gregory.Roof@TetraTech.com.

Sincerely,

Gregory S. Roof
Project Manager

GSR/lc

Enclosure

c: Gordon Crane, NCBC Gulfport
Bob Merrill, MDEQ
RDM, Tetra Tech (unbound, CD)
CTO JM48 Project File

Tetra Tech, Inc.

8640 Philips Highway, Suite 16, Jacksonville, FL 32256
Tel 904.636.6125 Fax 904.636.6165 www.tetrattech.com



Document Tracking Number 12JAX0033

April 24, 2012

Project Number 112G03334

Commanding Officer, Southeast
Naval Facilities Engineering Command
Attn: Charles Cook (Code OPA6)
Remedial Project Manager
NAS Jacksonville
135 Ajax Street
Jacksonville, Florida 32212-0030

Reference: CLEAN Contract Number N62470-08-D-1001
Contract Tack Order Number JM48

Subject: Response to Comments, Draft-Final UFP-SAP, Site 4 – Golf Course Landfill
Naval Construction Battalion Center Gulfport, Mississippi

Dear Mr. Cook:

Tetra Tech is pleased to submit this letter responding to the comments from the Mississippi Department of Environmental Quality (MDEQ) on the Draft-Final UFP-SAP for Site 4 – Golf Course Landfill at Naval Construction Battalion Center (NCBC) Gulfport. The questions and/or comments received by Tetra Tech are addressed below.

MDEQ, Mr. Bob Merrill

Comment 1: The text (page 30, paragraph 1, sentence 2) stating that “the Navy acquired the installation property in April 1942 and occupies approximately 1,100 acres” needs to be reworded.

Response: Text was changed to say “NCBC Gulfport occupies approximately 1,100 acres and is located in the western part of Gulfport, Mississippi, in Harrison County, in the southeastern corner of the state, approximately 2 miles north of the Gulf of Mexico. The Navy acquired the installation property in April 1942.”

Comment 2: The telephone number for the MDEQ RPM (shown on SAP Worksheet # 3, page 13, and SAP Worksheet # 4 on page 17) is incorrect (should read 601 961 5049).

Response: Correction made.

Comment 3: The monitoring well GPT-04-26 listed on Table 17-1 (page 62) and SAP Worksheet #18 (page 64) as one of eight wells to be sampled and included implicitly in the description given on page 53 (paragraph 2) of eight groundwater samples to be sampled, is not shown on the monitoring well location map (Figure 17-1) as one of the wells (with labels in red rectangles) to be included in the Long Term Monitoring Program. Clarification is needed concerning the intended use (if any) of well GPT-4-26 and

Tetra Tech, Inc.

8640 Philips Highway, Suite 16, Jacksonville, FL 32256
Tel 904.636.6125 Fax 904.636.6165 www.tetrattech.com



Mr. Charles Cook
NAVFAC SE
April 24, 2012 – Page 2

whether there will be seven (as indicated on Figure 17-1) or eight wells to be monitored as described in the text (page 53, paragraph 2) and shown on Table 17-1 (page 62) and Worksheet # 18 (page 64).

Response: Comment noted. GPT-04-26 will be included in monitoring. Figure 17-1 has been updated accordingly.

Comment 4: Several sections of pages and complete pages of Appendix B (Field Standard Operating Procedures) are marked through by a red "X" with "TD" date but no explanation of the meaning of the symbols (legend, text explanation, etc.) is given (ex. Page 22 through 26 or 36, Appendix B).

Response: Mark-ups provided in Appendix B indicate sections of Field Standard Operating Procedures that are not relevant or applicable to the monitoring at Site 4. 'TD' is the initials of the individual making the mark-up. The following text has been added as a footnote to Worksheet #21:

"Note: Appendix B provides SOPs for activities to be conducted during the Site 4 investigation. SOPs have been marked through with a red "X" to indicate a section of the SOP that is not relevant and/or applicable to Site 4. Mark-ups have been initialed and dated."

Comment 5: A Hydrogeologic Cross Section showing geologic units and the aquifers in which wells are screened that supports an accompanying text discussion concerning the conceptual site model would greatly enhance the understanding of the vertical extent of contamination and how the monitoring network will define the horizontal and vertical extent of the plume.

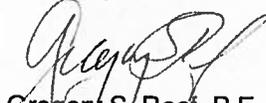
Response: A geologic cross section has been added as Figure 10-6.

Comment 6: It should be noted that MDEQ is adopting the EPA RSLs for PAH compounds. These screening values will be reflected in the TRG Tables on the MDEQ webpage at some point in the near future. This would particularly affect any future soil/sediment sampling in areas influence by Site 4 (sediments associated with seeps along Canal 1, sediment traps, etc.).

Response: Comment noted.

If you have any questions with regard to this submittal, please contact me via e-mail at Gregory.Roof@TetraTech.com or by phone at (904) 730-4669, extension 215.

Sincerely,



Gregory S. Roof, P.E.
Task Order Manager

GSR/td

c: Gordon Crane, NCBC Gulfport
Bob Merrill, MDEQ
RDM, Tetra Tech
CTO JM48 Project File

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

**SAMPLING AND ANALYSIS PLAN
(FIELD SAMPLING PLAN AND QUALITY ASSURANCE PROJECT PLAN)
FOR
GROUNDWATER PLUME EVALUATION
SITE 4 – GOLF COURSE LANDFILL**

**NAVAL CONSTRUCTION BATTALION CENTER GULFPORT
GULFPORT, MISSISSIPPI**

**COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT**

**Submitted to:
Naval Facilities Engineering Command Southeast
NAS Jacksonville
Jacksonville, Florida 32212-0030**

**Submitted by:
Tetra Tech
234 Mall Boulevard
King of Prussia, Pennsylvania 19406-2954**

**CONTRACT NUMBER N62470-08-D-1001
CONTRACT TASK ORDER JM48**

APRIL 2012

SAP WORKSHEET #1 – APPROVAL PAGE
(UFP-QAPP Manual Section 2.1)

Document Title: Sampling and Analysis Plan, (Field Sampling Plan and Quality Assurance Project Plan) for Groundwater Plume Evaluation, Site 4 – Golf Course Landfill, Naval Construction Battalion Center Gulfport, Gulfport, Mississippi

Lead Organization: Naval Facilities Engineering Command Southeast

Preparer's Name and Organizational Affiliation: Thomas Deck, Tetra Tech NUS, Inc.

Preparer's Address and Telephone Number: 8640 Philips Highway, Suite 16
Jacksonville, Florida 32256
(904) 730-4669 Ext. 228

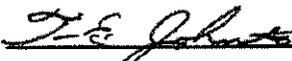
Preparation Date (Day/Month/Year): May 18, 2011

Investigative Organization's Project Manager:



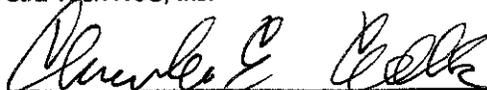
Signature/Date 5-18-2011
Gregory Roof
Tetra Tech NUS, Inc.

Investigative Organization's Project Quality Assurance Manager:

 5-18-2011

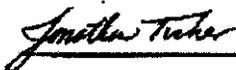
Signature/Date
Tom Johnston
Tetra Tech NUS, Inc.

Lead Organization's Project Manager:



Signature/Date
Charles Cook
Naval Facilities Engineering Command Southeast

Lead Organization Quality Assurance Officer:



Signature/Date
NAVFAC Chemist
Naval Facilities Engineering Command Atlantic

Digitally signed by
TUCKER,JONATHAN.P.1239524180
Date: 2011.07.18 07:26:10 -04'00'

Approval Signatures:

Approval was received separately via letter.

Signature/Date
Bob Merrill
Mississippi Department of Environmental Quality

EXECUTIVE SUMMARY

This Sampling and Analysis Plan (SAP) encompasses Field Sampling Plan and Quality Assurance Project Plan requirements for a Groundwater Plume Evaluation at Site 4 – Golf Course Landfill at Naval Construction Battalion Center (NCBC) Gulfport, located in Gulfport, Mississippi. This document constitutes the planning document, addressing specific protocols for sample collection, sample handling and storage, chain-of-custody, laboratory and field analyses, data validation, and data reporting.

This SAP has been prepared by Tetra Tech on behalf of Naval Facilities Engineering Command Southeast under the Comprehensive Long-term Environmental Action Navy Contract Number N62470-08-D-1001, Contract Task Order JM48. This SAP was generated for and complies with applicable United States Navy, Mississippi Department of Environmental Quality (MDEQ), and United States Environmental Protection Agency (USEPA) Region 4 requirements, regulations, guidance, and technical standards. This includes the Department of Defense (DoD), Department of Energy (DOE), and USEPA Interagency Data Quality Task Force environmental requirements regarding federal facilities. To comply with DoD/DOE/USEPA requirements, this SAP is presented in the format of standard worksheets specified in the Uniform Federal Policy (UFP) for Quality Assurance Plans (QAPP) guidance document (USEPA, 2005).

NCBC Gulfport is located in the western part of Gulfport, Mississippi, in the southeastern part of Harrison County; about 2 miles north of the Gulf of Mexico (Figure ES-1). The property for the installation was acquired in April 1942 and occupies approximately 1,100 acres. The primary mission of NCBC Gulfport is to support military readiness for four battalions of the Naval Construction Force (NCF) and the storage and maintenance of pre-positioned War Reserve Material Stock. The NCF support consists of mobilization and logistics support for both homeport services and deployed support. Approximately 5,000 military and 1,600 civilian personnel are assigned to, or employed by, NCBC Gulfport.

Nine sites at NCBC Gulfport, including Site 4, were identified in the Initial Assessment Study as potential threats to human health or the environment (Envirodyne Engineers, Inc., 1985) following the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process with the MDEQ as lead regulatory agency.

Site 4 is approximately 4 acres and is a former landfill located in the western section of NCBC Gulfport, northeast of the intersection of 7th Street and Canal No. 1. The drainage ditch known as Canal No. 1, which is the only surface water body within the site boundaries, defines the western boundary. Since the early 1990s, the southern portion of the site was covered by the greens of the 9th and 18th holes of the

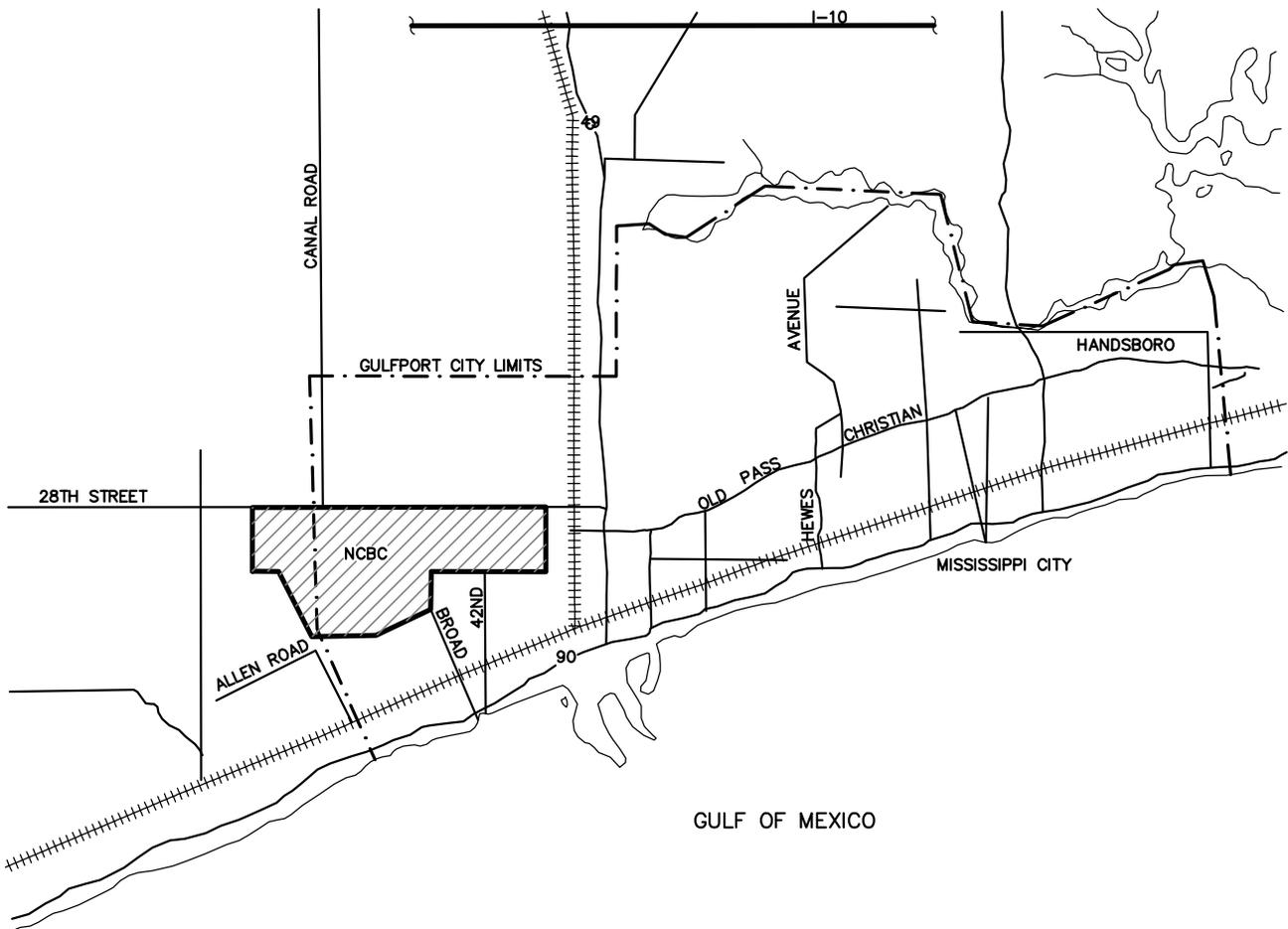
Pine Bayou Golf Course. Site 4 is planned to be used for recreational purposes as part of the “golf experience” operated by Morale, Welfare, and Recreation at NCBC Gulfport.

The Site 4 landfill operated from 1966 to 1972 and was the only operating landfill on the base during this time. Solid waste, such as construction debris and general refuse, made up the bulk of the materials disposed of at Site 4. According to previous investigations, nearly 16,000 tons of solid waste, including building and infrastructure debris from damage due to Hurricane Camille (1969), were disposed of at the landfill. Additionally, as much as 20,000 gallons of waste liquids were disposed of at the site, including fuels, oils, solvents, paints, paint thinners. After waste disposal activities ceased, the site was covered with 4 to 6 feet of fine- to medium-grained sand.

Site 4 has undergone the CERCLA corrective action process and the remedial action (RA) effort is completed. The Partnering Team decided that the Presumptive Remedy for CERCLA Municipal Landfill Sites as prescribed in the USEPA guidance document (USEPA, 1993) would be applied to the site. The selection of the Presumptive Remedy was supported by the Site 4 Conceptual Site Model and the data gathered during this streamlined Remedial Investigation (RI) and Feasibility Study (FS). The use of the streamlined RI/FS was developed by USEPA as a framework for the Presumptive Remedy. The selected remedy includes containment of the landfill contents (landfill cap) and prevention of contaminant migration in the future. The landfill cap is currently being constructed.

During the RI a plume of groundwater contamination was discovered beyond the landfill boundary migrating to the west-southwest beneath and beyond Canal No. 1. A treatability study (TS) at Site 4 was conducted to provide information for the selection of a remedial option for chlorinated volatile organic compounds (VOCs) in groundwater and to compliment the overall cap/cover presumptive remedy for Site 4. Bioaugmentation technology using substrate and microbial culture injection was tested in a small area of the site. Analytical data collected prior to and following the technology application were evaluated to determine how successfully the injected materials were performing to dechlorinate chlorinated VOCs present in groundwater at the site. Data collected during the TS indicate that enhanced anaerobic reductive dechlorination (ARD) can be an effective remedial approach.

The purpose of this investigation is to obtain data that will enable the Partnering Team to (a) evaluate the current extent of the existing groundwater plume above risk-based screening levels and (b) to assess the favorability of geochemical conditions for natural attenuation in a Site Conditions Memorandum. Based on the results of the investigation, the Partnering Team will determine if an additional response action is required to address the chlorinated VOCs groundwater plume.



DRAWN BY BH	DATE 4/4/11
CHECKED BY TD	DATE 4/4/11
REVISED BY	DATE
SCALE NOT TO SCALE	



VICINITY MAP
 SITE 4 – GOLF COURSE LANDFILL
 NCBC GULFPORT
 GULFPORT, MISSISSIPPI

CONTRACT NO. 3334	
OWNER NO.	
APPROVED BY	DATE
DRAWING NO. FIGURE ES-1	REV. 0

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- A Data Quality Objectives Presentation
- B Field Standard Operating Procedures and Field Forms
- C Naval Construction Battalion Center Excavation Permit
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ACRONYMS

%D	Percent Difference or Percent Drift
%R	Percent Recovery
%RSD	Percent Relative Standard Deviation
ABB-ES	ABB Environmental Services, Inc.
AES	Atomic Emission Spectroscopy
AMU	Atomic Mass Unit
ARD	Anaerobic Reductive Dechlorination
BFB	Bromofluorobenzene
bgs	below ground surface
°C	Degree Celsius
CA	Corrective Action
CAS	Chemical Abstracts Service
CCB	Continuing Calibration Blank
CCC	Continuing Calibration Compound
CCV	Continuing Calibration Verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFA	Cape Fear Analytical, LLC
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action Navy
CLP	Contract Laboratory Program
COC	Chain of Custody
COPC	Contaminant of Potential Concern
CPSM	Column Performance Check Solution
CS	Confirmation Study
CSM	Conceptual Site Model
CTO	Contract Task Order
DCE	Dichloroethene
Dhc	Dehalococcoides
DL	Detection Limit
DoD	Department of Defense
DOE	Department of Energy
DPT	Direct Push Technology
DQI	Data Quality Indicator
DQO	Data Quality Objective
DVM	Data Validation Manager

ACRONYMS (CONTINUED)

EDL	Estimated Detection Limit
ELAP	Environmental Laboratory Accreditation Program
Empirical	Empirical Laboratories, LLC
ERA	Ecological Risk Assessment
ESV	Ecological Screening Value
Ext.	Extension
FOL	Field Operations Leader
FS	Feasibility Study
FTMR	Field Task Modification Form
GC/FID	Gas Chromatography/Flame Ionization Detector
GC/MS	Gas Chromatography/Mass Spectrometry
GC/RGD	Gas Chromatography/Reduction Gas Detector
HASP	Health and Safety Plan
HCl	Hydrochloric Acid
HHRA	Human Health Risk Assessment
HLA	Harding Lawson Associates
HNO ₃	Nitric Acid
HRGC/HRMS	High Resolution Gas Chromatography/High Resolution Mass Spectrometry
HSM	Health and Safety Manager
IAS	Initial Assessment Study
IC	Ion Chromatography
ICAL	Initial Calibration
ICB	Initial Calibration Blank
ICP	Inductively Coupled Plasma
ICP-AES	Inductively Coupled Plasma-Atomic Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry
ICS	Interference Check Sample
ICV	Initial Calibration Verification
ID	Identification
IDW	Investigation Derived Waste
IS	Internal Standard
L	Liter
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection

ACRONYMS (CONTINUED)

LOQ	Limit of Quantitation
LTM	Long-term Monitoring
LUC	Land Use Control
µg/L	Micrograms per Liter
MCL	Maximum Contamant Level
MD	Matrix Duplicate
MDEQ	Mississippi Department of Environmental Quality
MEE	Methane, Ethane, Ethene
Microseeps	Microseeps, Inc.
Microbial Insights	Microbial Insights, Inc.
mL	Milliliter
MPC	Measurement Performance Criteria
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NA	Not Applicable
NAVFAC SE	Naval Facilities Engineering Command Southeast
NCBC	Naval Construction Battalion Center
NCF	Naval Construction Force
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ORP	Oxidation-reduction Potential
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated Dibenzodioxins
PCDF	Polychlorinated Dibenzofurans
pg/L	Picograms per Liter
PID	Photoionization Detector
PM	Project Manager
POC	Point of Contact
PPE	Personal Protective Equipment
PQLG	Practical Quantitation Limit Goal
PSL	Project Screening Level
PWD	Public Works Division
QA	Quality Assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan

ACRONYMS (CONTINUED)

QC	Quality Control
QSM	Quality Systems Manual
r	Linear Regression Correlation Coefficient
r ²	Coefficient of Determination
RA	Remedial Action
R-Dase	Reductase
RF	Response Factor
RI	Remedial Investigation
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RRT	Relative Retention Time
RSD	Relative Standard Deviation
RSL	Regional Screening Level
RT	Retention Time
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SPCC	System Performance Check Compound
SRCR	Sample Receipt Condition Report
SSO	Site Safety Officer
TBD	To Be Determined
TCDD	Tetrachlorodibenzo-p-dioxin
TCE	Trichloroethene
TEF	Toxic Equivalent Factor
TEQ	Toxic Equivalent
TOC	Total Organic Carbon
TRG	Target Remediation Goal
TS	Treatability Study
UFP	Uniform Federal Policy
USEPA	United States Environmental Protection Agency
VC	Vinyl Chloride
VOC	Volatile Organic Compound

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

Site Name/Number: Naval Construction Battalion Center (NCBC) Gulfport, Mississippi
Operable Unit: Site 4 – Golf Course Landfill
Contractor Name: Tetra Tech
Contract Number: N62470-08-D-1001
Contract Title: Comprehensive Long-term Environmental Action Navy (CLEAN)
Work Assignment Number Contract Task Order (CTO) JM48

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)* (United States Environmental Protection Agency [USEPA], 2005) and *Guidance for Quality Assurance Project Plans, QA/G-5, QAMS* (USEPA, 2002).
2. Identify regulatory program: National Oil and Hazardous Substances Pollution Contingency Plan (NCP); Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).
3. This SAP is a project-specific SAP.
4. List dates of scoping sessions that were held:

SCOPING SESSION	DATE
Partnering Team Meeting	March 21 and 22, 2011
Data Quality Objective (DQO) Presentation (via e-mail)	April 19, 2011

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

TITLE	DATE
Initial Assessment Study (IAS)	July 1985
Final Remedial Investigation (RI) Report/ Final Feasibility Study (FS)	2009

6. List organizational partners (stakeholders) and connection with lead organization:

Mississippi Department of Environmental Quality (MDEQ) (lead regulatory stakeholder)
NCBC Gulfport (property owner)
USEPA Region IV (regulatory stakeholder)

7. Lead organization

Naval Facilities Engineering Command Southeast (NAVFAC SE)

8. 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:

Not Applicable (NA). There are no exclusions.

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

NAME OF SAP RECIPIENTS	TITLE/ROLE	ORGANIZATION	TELEPHONE NUMBER	E-MAIL ADDRESS OR MAILING ADDRESS
Charles Cook	Navy Remedial Project Manager (RPM)/ Manages Project Activities for the Navy	NAVFAC SE Code OPA6, 135 Ajax Street Jacksonville, FL 32212-0030	(904) 542-6409	charles.cook2@navy.mil
Gordon Crane	NCBC Gulfport Point of Contact (POC)/ Environmental Coordinator	NCBC Gulfport 2401 Upper Nixon Avenue Gulfport, MS 39501	(228) 871-2485	gordon.crane@navy.mil
To Be Determined (TBD) (copy of final cover letter only)	Head of Reference Desk (NCBC Gulfport Administrative Record)	TBD	TBD	TBD
Bob Merrill	MDEQ RPM/ Provides Regulator Input	MDEQ 515 E Amite Street Jackson, MS 39201-2709	(601) 961-5049	bob_merrill@deq.state.ms.us
Paul Necaie	Ecologist/ Environmental Support	United States Fish and Wildlife Services 6578 Dogwood View Parkway Jackson, MS 39213	(228) 493-6631	paul_necaie@fws.gov

NAME OF SAP RECIPIENTS	TITLE/ROLE	ORGANIZATION	TELEPHONE NUMBER	E-MAIL ADDRESS OR MAILING ADDRESS
TBD	USEPA RPM*/ Receives Final Document	USEPA Region 4 Atlanta Federal Center 61 Forsyth Street, SW Atlanta, GA 30303-8960	TBD	TBD
Gregory Roof	Tetra Tech Project Manager (PM)/ Manages Project Activities	Tetra Tech 8640 Philips Highway, Suite 16 Jacksonville, FL 32256	(904) 730-4669 Extension (Ext.) 215	gregory.roof@tetrattech.com
William Olson	Tetra Tech Field Operations Leader (FOL)/Site Safety Officer (SSO)/ Manages Field Operation and Site Safety Issues	Tetra Tech 1558 Village Square Boulevard Suite 2 Tallahassee, FL 32309	(850) 385-9899 Ext. 1359	william.olson@tetrattech.com
Tom Johnston (electronic copy only)	Tetra Tech Quality Assurance Manager (QAM)/ Manages Corporate Quality Assurance (QA) Program and Implementation	Tetra Tech 661 Andersen Drive Foster Plaza 7 Pittsburgh, PA 15220	(412) 921-8615	tom.johnston@tetrattech.com
Kelly Carper	Tetra Tech Project Chemist/Provides Coordination with Laboratories	Tetra Tech 661 Andersen Drive Foster Plaza 7 Pittsburgh, PA 15220	(412) 921-7273	kelly.carper@tetrattech.com
Joseph Samchuck (electronic copy only)	Tetra Tech Data Validation Manager (DVM)/ Manages Data Validation	Tetra Tech 661 Andersen Drive Foster Plaza 7 Pittsburgh, PA 15220	(412) 921-8510	joseph.samchuck@tetrattech.com

NAME OF SAP RECIPIENTS	TITLE/ROLE	ORGANIZATION	TELEPHONE NUMBER	E-MAIL ADDRESS OR MAILING ADDRESS
Matt Soltis [Health and Safety Plan (HASP) only]	Tetra Tech Health and Safety Manager (HSM)/ Manages Corporate Health and Safety Program	Tetra Tech 661 Andersen Drive Foster Plaza 7 Pittsburgh, PA 15220	(412) 921-8912	matt.soltis@tetrattech.com
Brian Richard (electronic copy only)	Laboratory PM/ Representative for Laboratory and Analytical Issues	Empirical Laboratories, LLC (Empirical) 621 Mainstream Drive Suite 270 Nashville, TN 37228	(615) 345-1115	brichard@empirilabs.com
Chris Cornwell (electronic copy only)	Laboratory PM/ Representative for Laboratory and Analytical Issues	Cape Fear Analytical, LLC (CFA) 3306 Kitty Hawk Road Suite 120 Wilmington, NC 28405	(910) 795-0422	chris.cornwell@cfanalytical.com
Robbin Robl (electronic copy only)	Laboratory PM/ Representative for Laboratory and Analytical Issues	Microseeps, Inc. (Microseeps) 220 William Pitt Way Pittsburgh, PA 15236	(412) 826-5245	rrobl@microseeps.com
Anita Biernacki (electronic copy only)	Laboratory PM/ Representative for Laboratory and Analytical Issues	Microbial Insights, Inc. (Microbial Insights) 2340 Stock Creek Blvd. Rockford, TN 37853	(865) 573-8188	abiernacki@microbe.com
Driller(s) – TBD (electronic copy only)	DPT and Well Installation Subcontractor PM(s)/ Provides Drilling Services	TBD	TBD	TBD
Utility Locator – TBD (electronic copy only)	Utility Locator Subcontractor PM/ Provides Utility Locating Services	TBD	TBD	TBD

NAME OF SAP RECIPIENTS	TITLE/ROLE	ORGANIZATION	TELEPHONE NUMBER	E-MAIL ADDRESS OR MAILING ADDRESS
Surveyor – TBD (electronic copy only)	Surveyor Subcontractor PM/ Provides Surveying Services	TBD	TBD	TBD

*USEPA involvement in NCBC Gulfport has been limited to requesting final documents.

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

Certification that project personnel have read the text will be obtained by one of the following methods as applicable:

1. In the case of regulatory agency personnel with oversight authority, approval letters or e-mails will constitute verification that applicable sections of the SAP have been reviewed. Copies of regulatory agency approval letters / e-mails will be retained in the project files and are listed in Worksheet #29 as project records.
2. E-mails will be sent to the Navy, Tetra Tech, and subcontractor project personnel whom will be requested to verify by e-mail that they have read the applicable SAP / sections and the date on which they were reviewed. Copies of the verification e-mail will be included in the project files and identified in Worksheet #29.

A copy of the signed Worksheet #4 will be retained in the project files and identified as a project document in Worksheet #29.

NAME	ORGANIZATION/ TITLE/ ROLE	TELEPHONE NUMBER	SIGNATURE/E-MAIL RECEIPT	SAP SECTION REVIEWED	DATE SAP READ
Navy and Regulator Partnering Team Personnel					
Charles Cook	Navy RPM/ Manages Project Activities for the Navy	(904) 542-6409	See Worksheet #1 for signature	All	
Gordon Crane	Navy/ NCBC Gulfport POC/ Environmental Coordinator	(228)8 71-2485		All	
Bob Merrill	MDEQ/ RPM/ Provides Regulator Input	(601) 961-5049	Approval was received separately via letter	All	

NAME	ORGANIZATION/ TITLE/ ROLE	TELEPHONE NUMBER	SIGNATURE/E-MAIL RECEIPT	SAP SECTION REVIEWED	DATE SAP READ
TBD	USEPA Region 4*	TBD	NA	NA	
Tetra Tech Partnering Team Personnel					
Gregory Roof	Tetra Tech/ PM/ Manages Project Activities	(904) 730-4669 Ext. 215	See Worksheet #1 for signature	All	
William Olson	Tetra Tech/ FOL/SSO, Lead Geologist/ Manages Field Operation and Site Safety Issues	(850) 385-9866 Ext.1359		All	
Kelly Carper	Tetra Tech/ Project Chemist/ Provides Coordination with Laboratories	(412) 921-7273		All	
Tom Johnston	Tetra Tech/ QAM/ Manages NAVFAC SE Contract QA Program and Implementation	(412) 921-8615	See Worksheet #1 for signature	All	
Joseph Samchuck	Tetra Tech/DVM/ Manages Data Validation	(412) 921-8510		Worksheets #14, #15, #19, #20, #23-28, #30, and #34-37	

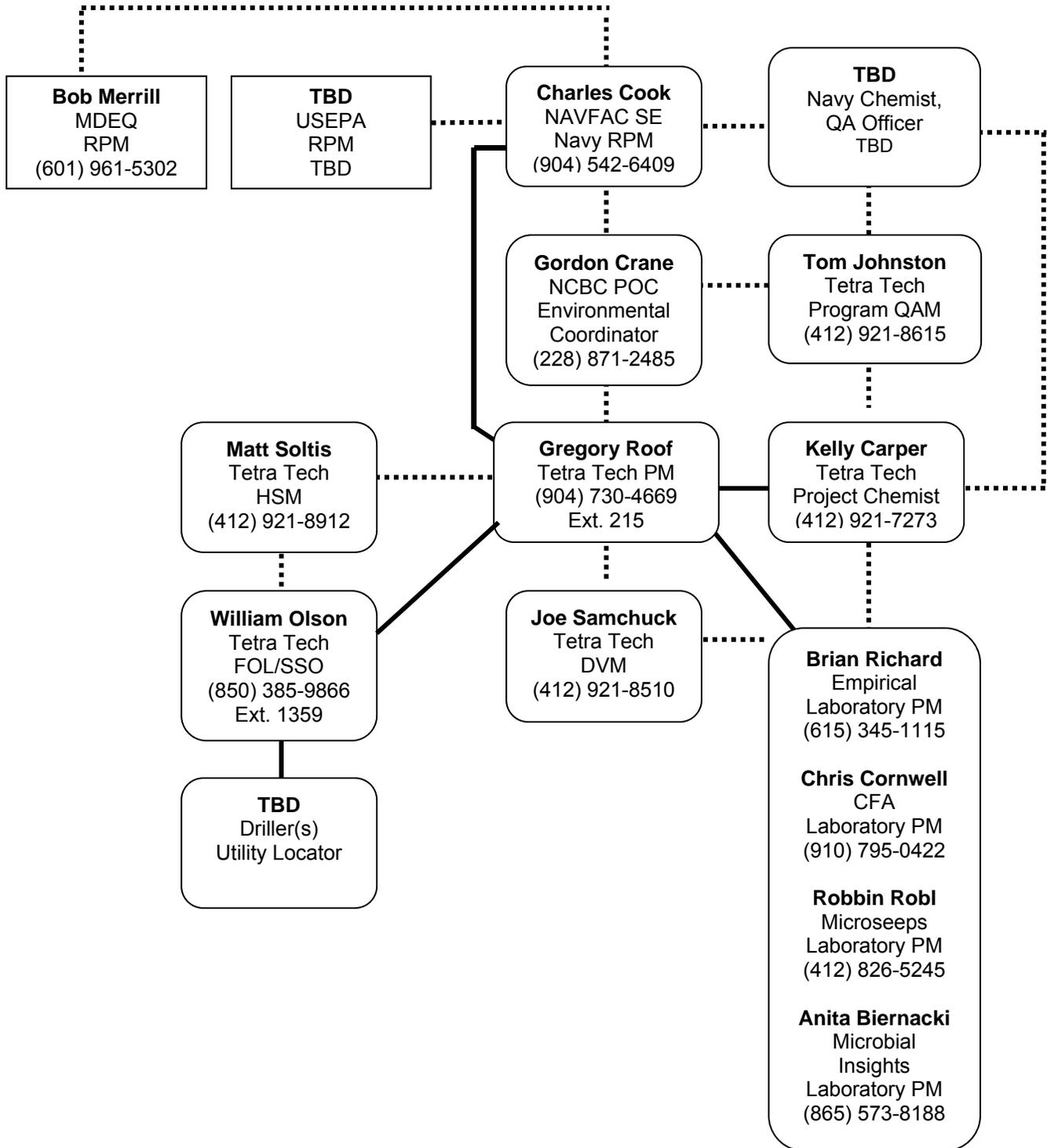
*USEPA involvement in NCBC Gulfport has been limited to requesting final documents,

NAME	ORGANIZATION/ TITLE/ ROLE	TELEPHONE NUMBER	SIGNATURE/E-MAIL RECEIPT	SAP SECTION REVIEWED	DATE SAP READ
Subcontractor Personnel					
Brian Richard	Empirical/ Laboratory PM/ Representative for Laboratory and Analytical Issues	(615) 345-1115		Worksheets #6, #12, #14, #15, #19, #23-28, #30, and #34-36	
Chris Cornwell	CFA/ Laboratory PM/ Representative for Laboratory and Analytical Issues	(910) 795-0422		Worksheets #6, #12, #14, #15, #19, #23-28, #30, and #34-36	
Robbin Robl	Microseeps/ Laboratory PM/ Representative for Laboratory and Analytical Issues	(412) 826-5245		Worksheets #6, #12, #14, #15, #19, #23-28, #30, and #34-36	
Anita Biernacki	Microbial Insights/ Laboratory PM/ Representative for Laboratory and Analytical Issues	(865) 573-8188		Worksheets #6, #12, #14, #15, #19, #23-28, #30, and #34-36	
Driller(s) - TBD	TBD/ DPT and Well Installation Subcontractor PM/ Provides Drilling Services	TBD		Worksheets #6, #14, #17, and Figures	
Utility Locator - TBD	TBD/ Utility Locator Subcontractor PM/ Provides Utility Locating Services	TBD		Worksheets #6, #14, #17, and Figures	
Surveyor - TBD	TBD/ Utility Locator Subcontractor PM/ Provides Utility Locating Services	TBD		Worksheets #6, #14, #17, and Figures	

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 DRIVERS	RESPONSIBLE PERSON AFFILIATION	NAME	PHONE NUMBER AND/OR E-MAIL	PROCEDURE
Identification of site equipment storage locations and utility clearance	Tetra Tech FOL/SSO Tetra Tech PM NCBC Gulfport POC Mississippi One Call	William Olson Gregory Roof Gordon Crane One Call Representative	(850) 385-9866 Ext. 1359 (904) 730-4669 Ext. 215 (228) 871-2485 As applicable - TBD	At least one day prior to the start of field work, the Tetra Tech FOL or PM will coordinate verbally or via e-mail with the NCBC Gulfport POC to identify locations for storing equipment and supplies. Additionally, utility mark-outs must be completed prior to any intrusive activities.
SAP amendments	Tetra Tech FOL/SSO Tetra Tech PM Navy RPM	William Olson Gregory Roof Charles Cook	(850) 385-9866 Ext. 1359 (904) 730-4669 Ext. 215 (904) 542-6409	The Tetra Tech FOL will verbally inform the Tetra Tech PM within 24 hours of realizing a need for an amendment. The Tetra Tech PM will document the proposed changes via a Field Task Modification Request (FTMR) form within five days and send the Navy RPM a concurrence letter within seven days of identifying the need for change. SAP amendments will be submitted by the Tetra Tech PM to the Navy RPM for review and approval. The Tetra Tech PM will send scope changes to the Partnering Team via e-mail within one business day.

COMMUNICATION DRIVERS	RESPONSIBLE PERSON AFFILIATION	NAME	PHONE NUMBER AND/OR E-MAIL	PROCEDURE
Changes in schedule	Tetra Tech PM Navy RPM NCBC Gulfport POC	Gregory Roof Charles Cook Gordon Crane	(904) 730-4669 Ext. 215 (904) 542-6409 (228) 871-2485	The Tetra Tech PM will verbally inform the Navy RPM and the NCBC Gulfport POC on the day that schedule change is known.
Issues in the field that lead to changes in the scope of work	Tetra Tech FOL/SSO Tetra Tech PM Navy RPM NCBC Gulfport POC	William Olson Gregory Roof Charles Cook Gordon Crane	(850) 385-9866 Ext. 1359 (904) 730-4669 Ext. 215 (904) 542-6409 (228) 871-2485	<p>The Tetra Tech FOL will verbally inform the Tetra Tech PM on the day that the issue is discovered.</p> <p>The Tetra Tech PM will inform the Navy RPM and the NCBC Gulfport POC (verbally or via e-mail) within one business day of discovery.</p> <p>The Navy RPM will issue scope change (verbally or via e-mail), if warranted. The scope change is to be implemented before further work is executed.</p> <p>The Tetra Tech PM will document the change via an FTMR form within two days of identifying the need for change and will obtain required approvals within five days of initiating the form.</p>

COMMUNICATION DRIVERS	RESPONSIBLE PERSON AFFILIATION	NAME	PHONE NUMBER AND/OR E-MAIL	PROCEDURE
Recommendation to stop work and initiate work upon corrective action	Tetra Tech FOL/SSO Tetra Tech PM Tetra Tech QAM Tetra Tech Project Chemist Navy RPM NCBC Gulfport POC	William Olson Gregory Roof Tom Johnston Kelly Carper Charles Cook Gordon Crane	(850) 385-9866 Ext. 1359 (904) 730-4669 Ext. 215 (412) 921-8615 (412) 921-7273 (904) 542-6409 (228) 871-2485	<p>If Tetra Tech is the responsible party for a stop work command, the Tetra Tech FOL will inform on-site personnel, subcontractor(s), the NCBC Gulfport POC, and the identified Partnering Team members within one hour (verbally or by e-mail).</p> <p>If a subcontractor is the responsible party, the subcontractor PM must inform the Tetra Tech FOL within 15 minutes, and the Tetra Tech FOL will then follow the procedure listed above.</p>
Corrective action for field program	Tetra Tech QAM Tetra Tech PM	Tom Johnston Gregory Roof	(412) 921-8615 (904) 730-4669 Ext. 215	<p>The Tetra Tech QAM will notify the Tetra Tech PM verbally or by e-mail within one business day that the corrective action has been completed.</p> <p>The Tetra Tech PM will then notify the Navy RPM within one business day (verbally or via e-mail).</p>
Field data quality issues	Tetra Tech FOL/SSO Tetra Tech PM	William Olson Gregory Roof	(850) 385-9866 Ext. 1359 (904) 730-4669 Ext. 215	<p>The Tetra Tech FOL will inform the Tetra Tech PM verbally or by e-mail on the same day that a field data quality issue is discovered.</p>

COMMUNICATION DRIVERS	RESPONSIBLE PERSON AFFILIATION	NAME	PHONE NUMBER AND/OR E-MAIL	PROCEDURE
Analytical data quality issues	Empirical Laboratory PM	Brian Richard	(615) 345-1115	The Laboratory PM will notify (verbally or via e-mail) the Tetra Tech Project Chemist within one business day of when an issue related to laboratory data is discovered.
	CFA PM	Chris Cornwell	(910) 795-0422	
	Microbial Insights PM	Anita Biernacki	(865) 573-8188	The Tetra Tech Project Chemist will notify (verbally or via e-mail) the DVM and the Tetra Tech PM within one business day.
	Microseeps	Robbin Robl	(412) 826-5245	
	Project Chemist	Kelly Carper	(412) 921-7273	Tetra Tech DVM or Project Chemist notifies Tetra Tech PM verbally or via e-mail within 48 hours of validation completion that a non-routine and significant laboratory quality deficiency has been detected that could affect this project and/or other projects. The Tetra Tech PM verbally advises the NCBC Gulfport POC within 24 hours of notification from the Tetra Tech Project Chemist or DVM. The NCBC Gulfport POC takes corrective action that is appropriate for the identified deficiency. Examples of significant laboratory deficiencies include data reported that has a corresponding failed tune or initial calibration verification. Corrective actions may include a consult with the Navy Chemist.
	Tetra Tech DVM	Joseph Samchuck	(412) 921-8510	
	Tetra Tech PM	Gregory Roof	(904) 730-4669 Ext. 215	
	NCBC Gulfport POC	Gordon Crane	(228) 871-2485	
Navy Chemist	TBD	TBD		

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

The personnel including Tetra Tech and the analytical laboratories, responsible for implementing the SAP are identified in the following table. Resumes are available upon request.

Name	Title/Role	Organizational Affiliation	Responsibilities
Charles Cook	Navy RPM/ Manages Project Activities for the Navy	NAVFAC SE	Oversees project implementation including scoping, data review, and evaluation.
Gordon Crane	NCBC Gulfport POC/ Environmental Coordinator	NCBC Gulfport	Oversees site activities and participates in scoping, data review, evaluation, and reviews the SAP.
Bob Merrill	MDEQ RPM/ Provides Regulator Input	MDEQ	Participates in scoping, data review, evaluation, and approves the SAP.
TBD	USEPA Region 4* RPM/ Receives Final Document	USEPA	USEPA involvement in NCBC Gulfport has been limited to receiving final documents for informational purposes.
Gregory Roof	PM/ Manages project on a daily basis	Tetra Tech	Oversees project and manages financial, schedule, and technical day-to-day activities of the project.
William Olson	FOL/SSO/ Manages field operations and oversees site activities to ensure safety requirements are met	Tetra Tech	As FOL, supervises, coordinates, and performs field sampling activities. As the SSO, is responsible for on-site project-specific health and safety training and monitoring site conditions. Details of these responsibilities are presented in the HASP.
Tom Johnston	QAM/ Oversees program and project QA activities	Tetra Tech	Reviews the SAP and ensures quality aspects of the CLEAN program are implemented, documented, and maintained.
Tom Dickson	HSM/ Oversees health and safety activities	Tetra Tech	Oversees CLEAN Program Health and Safety Program.

Name	Title/Role	Organizational Affiliation	Responsibilities
Kelly Carper	Project Chemist/ Provides coordination with laboratories	Tetra Tech	Participates in project scoping, prepares laboratory scopes of work, and coordinates laboratory-related functions with laboratory. Oversees data quality reviews and QA of data validation deliverables.
Joseph Samchuck	DVM/ Oversees data validation activities	Tetra Tech	Manages data validation activities within Tetra Tech, including ensuring QA of data validation deliverables, providing technical advice on data usability, and coordinating and maintaining the data validation review schedule.
Brian Richard	Laboratory PM/ Representative for laboratory and analytical issues	Empirical	Coordinates analyses with laboratory chemists, ensures that scope of work is followed, provides QA of data packages, and communicates with Tetra Tech project staff.
Chris Cornwell	Laboratory PM/ Representative for laboratory and analytical issues	CFA	Coordinates analyses with laboratory chemists, ensures that scope of work is followed, provides QA of data packages, and communicates with Tetra Tech project staff.
Robbin Robl	Laboratory PM/ Representative for laboratory and analytical issues	Microseeps	Coordinates analyses with laboratory chemists, ensures that scope of work is followed, provides QA of data packages, and communicates with Tetra Tech project staff.
Anita Biernacki	Laboratory PM/ Representative for laboratory and analytical issues	Microbial Insights	Coordinates analyses with laboratory chemists, ensures that scope of work is followed, provides QA of data packages, and communicates with Tetra Tech project staff.
TBD	Driller(s)/ Provides drilling services and well installation	TBD	Performs well installation according to scope of work.
TBD	Surveyor/ Provides survey services	TBD	Determines location data for well locations according to scope of work.

Name	Title/Role	Organizational Affiliation	Responsibilities
TBD	Utility Locator/ Provides utility locating services	TBD	Performs utility location.

*USEPA involvement in NCBC Gulfport has been limited to requesting final documents.

In some cases, one person may be designated responsibilities for more than one position. For example, the FOL will be responsible for SSO duties. This action will be performed only as credentials, experience, and availability permits.

SAP Worksheet #8 -- Special Personnel Training Requirements Table
(UFP-QAPP Manual Section 2.4.4)

Each site worker will be required to have completed appropriate Hazardous Waste Operations and Emergency Response (HAZWOPER) training specified in Occupational Safety and Health Administration (OSHA) 29 Code of Federal Regulations (CFR) 1910.120 (e). Project-specific safety requirements are addressed in greater detail in the site-specific HASP.

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

Project Name: NCBC Gulfport Projected Date(s) of Sampling: Spring 2011 Project Manager: Gregory Roof		Site Name: Site 4- Golf Course Landfill Site Location: NCBC Gulfport, Mississippi			
Date of Session: 04/19/2011 – via e-mail Scoping Session Purpose: Data Quality Objectives (DQO) Presentation via e-mail					
Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Charles Cook	Navy RPM	NAVFAC SE	(904) 542-6409	charles.cook2@navy.mil	Navy Oversight
Bob Merrill	MDEQ RPM	MDEQ	(601) 961-5302	bob_merrill@deq.state.ms.us	Regulator
Gordon Crane	NCBC Gulfport POC/ Environmental Coordinator	NCBC Gulfport	(228) 871-2485	gordon.crane@navy.com	NCBC Gulfport POC
Gregory Roof	PM	Tetra Tech	(904) 730-4669 Ext. 215	gregory.roof@tetrattech.com	Project Management

Decisions:

It was decided that a reference and brief overview of contaminants of concern (COC) determined from contaminants of potential concern (COPC) in the Long-term Monitoring (LTM) Plan would be included in the UFP-SAP. It was stated that there were no detections exceeding regulatory screening levels in any of the groundwater samples taken at Site 4 during the RI. The DQO Presentation is available in Appendix A.

It was decided that a decision tree for groundwater would be added to the UFP-SAP. The decision rule will describe that if COC concentrations surrounding the perimeter of the known chlorinated VOCs groundwater plume are less than the corresponding project screening levels (PSLs), then proceed to long-term monitoring in accordance with the Site 4 Decision Document. If not, then Tetra Tech will continue to define the extent of contamination. Once complete, the Navy will recommend to the Partnering Team if additional treatment is warranted to accelerate remediation times based on the significance of the PSL exceedance(s).

COCs were carried over from the Decision Document as trichloroethene (TCE), cis- and trans-1,2-dichloroethene (DCE), and vinyl chloride (VC); the metals of iron and manganese; and dioxins/furans.

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

10.1 SITE BACKGROUND

NCBC Gulfport occupies approximately 1,100 acres and is located in the western part of Gulfport, Mississippi, in Harrison County, in the southeastern corner of the state, approximately 2 miles north of the Gulf of Mexico. The Navy acquired the installation property in April 1942. Site 4 is approximately 4 acres and is a former landfill located in the western section of NCBC Gulfport, northeast of the intersection of 7th Street and Canal No. 1. The western boundary is defined by the drainage ditch known as Canal No. 1, which is the only surface water body within the site boundaries. Portions of the 9th and 18th holes of the Pine Bayou Golf Course have covered the site since the early 1990s. Site 4 is planned to be used for recreational purposes as part of the “golf experience” operated by Morale, Welfare, and Recreation at NCBC Gulfport once construction of the engineered landfill cap is completed. The site layout is provided on Figure 10-1.

Site 4, known as the “Golf Course Landfill”, operated from 1966 to 1972 and was the only operating landfill on the base during this time. Solid waste such as construction debris and general refuse made up the bulk of the materials disposed of at Site 4. According to previous investigations, nearly 16,000 tons of solid waste, including building and infrastructure debris from damage due to Hurricane Camille (1969), were disposed of at the landfill. Additionally, as much as 20,000 gallons of waste liquids were disposed of at the site, including fuels, oils, solvents, paints, and paint thinners. After waste disposal activities ceased, the site was covered with 4 to 6 feet of fine- to medium-grained sand. The site, which is covered with grass typical of a golf course, is mostly free of dense or high vegetation and is surrounded by trees and various other types of vegetation on all sides except the northeastern edge.

Site 4 is one of six landfills at NCBC Gulfport. Data gathered during the RI showed that Site 4 could be managed under the presumptive remedy approach. Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and USEPA’s scientific and engineering evaluation of performance data on technology implementation. The objective of the presumptive remedies initiative is to use the program’s past experience to streamline site investigation and speed up selection of cleanup actions (USEPA, 1993). In 2010, the selected remedy for the site was determined to be the integration of an engineered landfill cap, landfill gas management, sediment removal and lining of Canal No. 1, semiannual groundwater monitoring, and land use controls (LUCs) to prevent residential development, withdrawal of groundwater, and future excavation (Tetra Tech, 2010).

10.2 SUMMARY OF PREVIOUS INVESTIGATIONS

10.2.1 Initial Assessment Study

During the IAS, sites at NCBC Gulfport that were potential threats to human health and the environment were identified (Envirodyne Engineers, Inc., 1985). The IAS included a records search, on-site survey, site ranking, and an outline for a subsequent Confirmation Study. The IAS recommended that the Confirmation Study at Site 4 include quarterly groundwater monitoring for one year from three new monitoring wells (one upgradient and two downgradient). The IAS also recommended that surface water (quarterly for one year) and sediment (one discrete sample) be collected from Canal No. 1 to determine if contamination had migrated to the canal.

10.2.2 Confirmation Study

A confirmation study (CS) [Harding Lawson Associates (HLA), 1988] included the results of site reconnaissance, a geophysical survey, and an investigation of soil, surface water, groundwater, and sediment locations on the southern and western sides of Site 4, as recommended in the IAS. The results of the CS indicated that contaminant concentrations were consistent with background levels. The CS incorrectly assumed that surface water and groundwater flowed south, resulting in upgradient and cross-gradient samples that yielded no contaminants in excess of action levels at that time.

10.2.3 Surface Water and Sediment Dioxin Delineation Report

A Surface Water and Sediment Dioxin Delineation Report (HLA, 1999) was a comprehensive study regarding drainage systems at NCBC Gulfport that were potentially related to Site 8 and herbicide orange (HO) storage. One of the main purposes of the study was to verify if active landfills during the period of HO storage, such as Site 4, received any HO drums. Surface water, sediment, seep, and groundwater samples were collected from the ditches in and around Site 4, and the results indicated disposal of HO in the landfill was unlikely. Dioxins Toxic Equivalent (TEQ) were detected at concentrations ranging from 0.65 to 26.4 picograms per liter (pg/L) in groundwater samples [less than the Target Remediation Goal (TRG) of 30 pg/L] with no tetrachlorodibenzo-p-dioxin (TCDD) detected. One of the seep samples had a TEQ result of 82.9 pg/L, significantly greater than the drinking water screening level of 30 pg/L. This concentration of dioxins in surface water is also greater than current USEPA ecological screening criterion of 0.05 pg/L. The types of dioxin congeners (octa- and hepta-chlorinated dioxins and furans) in the seep sample were consistent with the byproducts of incineration. Typically, solid wastes were burned in the disposal trenches before being covered. In other analyses, chlorinated VOCs were detected in monitoring well GPT-04-05. The maximum concentrations were VC at 37 micrograms per liter (µg/L), total 1,2-DCE at 180 ug/L, and TCE at 4.7 ug/L.

10.2.4 Interim Removal Action Report

The Interim Removal Action Report (1997) included a limited soil and groundwater investigation prior to the placement of activated carbon beds along the bank of Canal No. 1 on the southern side of Site 4 to prevent groundwater seeps from impacting surface water quality. The study included the collection of 10 soil samples and 3 groundwater samples. Arsenic concentrations in soil were greater than MDEQ Tier 1 TRG risk screening levels of 50 ug/L. Low levels of dioxins and furans were detected below risk screening levels. The 2,3,7,8-TCDD congener, which is the dioxin congener directly linked to HO, was not detected, supporting the previous conclusion that HO was not disposed at Site 4. Post-interim action sampling of the seeps was conducted over a 3-year period, and dioxins and furans were consistently reported as non-detects (Tetra Tech, 2009a).

10.2.5 Groundwater Monitoring Report

The Groundwater Monitoring Report (HLA, 1999) was an in-depth study of groundwater conditions at Site 4 specifically to verify the potential contamination of dioxins and furans because of the HO storage. Direct-push technology (DPT) results indicated widespread low levels of dioxin and furan congeners in groundwater. The main congeners observed in the DPT samples were octa- and hepta-chlorinated dioxins and furans consistent with the byproducts of incineration, indicating that HO is not a likely source. No TCDD was detected in any of the groundwater samples.

10.2.6 Final Remedial Investigation Report

Tetra Tech performed an RI from 2004 through 2007 to delineate the nature and extent of soil, groundwater, surface water, and sediment contamination at Site 4 and to characterize risks to human health and the environment (Tetra Tech, 2009). Information gathered during previous investigations, as mentioned above, was redefined the comprehensive multi-media investigation. The Final RI Report indicated the site was a good candidate for presumptive remedy and included a human health risk assessment (HHRA) and a screening-level ecological risk assessment (ERA). Information regarding the HHRA are discussed in Section 10.3.1.

10.2.7 Treatability Study Memorandum

Tetra Tech performed a Treatability Study (TS) in 2007 to provide information for the selection of a remedial option for chlorinated VOCs in groundwater to compliment the overall cap/cover presumptive remedy for Site 4. A bioaugmentation technology using substrate and microbial culture injection was tested in a small area of the site. Analytical data collected prior to and following the technology application were evaluated to determine how successfully the injected materials were in dechlorinating

chlorinated VOCs present in groundwater at the site. Data collected during the TS indicate that enhanced ARD can be an effective remedial approach for this site as demonstrated by the following:

- The substrate injection appears to have rapidly improved aquifer conditions for ARD.
- Application of the Dehalococcoides (Dhc) culture has established a higher proportion of Dhc in the subsurface micro biota.
- Evidence of anaerobic reductive dechlorination (ARD) was observed in two sampling locations, MP-01/MP-01D and GPT-04-22, where mass balance changes in chlorinated VOCs suggest dechlorination is occurring.
- Increased chloride and ethene concentrations as break down products in the treatment cell area also support the occurrence of ARD

10.2.8 Final Feasibility Study

Tetra Tech completed an FS in 2009 that evaluated alternatives to address the contaminated media (soil, sediment, surface water, and groundwater) and to identify the COCs (Tetra Tech, 2009b). Based on the USEPA presumptive remedy guidance for landfills (USEPA, 1993), the presumptive remedy of covering the landfill and addressing the existing groundwater and sediment contamination was evaluated following the CERCLA process.

10.2.9 Proposed Plan

Based on the Final FS (Tetra Tech, 2010), the preferred alternative of an engineered landfill cap, landfill gas management, ditch lining of Canal No. 1, LUCs, and semiannual groundwater monitoring for COCs was presented to the community through the Proposed Plan.

10.2.10 Site 4 Decision Document

A Decision Document (Tetra Tech, 2010) presented the selected remedy for Site 4. The selected remedy included an engineered landfill cap, landfill gas management, ditch lining of Canal No. 1, LUCs, and semiannual groundwater monitoring for COCs.

10.3 RISK ASSESSMENT

10.3.1 Human Health Risk Assessment

As part of the Final RI Report (Tetra Tech, 2009a) an HHRA was performed to evaluate exposure to contaminants in subsurface soil, groundwater, surface water, and sediment at Site 4. Estimated risks for site workers, occupational workers, construction/excavation workers, and trespassers/recreational users assumed to be exposed to site media were less than, or within, USEPA and MDEQ risk-based benchmark screening values. The quantitative risk evaluation indicated that potential adverse health effects might be associated with the hypothetical future residential use of groundwater. The maximum detected concentrations of several VOCs (1,2-dichloroethane and benzene) and arsenic in groundwater exceeded USEPA and MDEQ benchmarks; however, there was considerable uncertainty in the risk estimates calculated for exposure to contaminants in groundwater and the numerical risk results are likely overestimated. In addition, the residential groundwater use scenario was evaluated to be conservative and to provide information to risk managers for Site 4. The groundwater underlying and downgradient of Site 4 is not currently used as a source of drinking water, and there are no plans to develop this resource in the future. Residential risks estimated for other media (subsurface soil, surface water, and sediment) were within USEPA and MDEQ benchmarks.

In general, a constituent is selected as a COPC and retained for further quantitative risk evaluation in the HHRA if the maximum detected concentration in a sampled medium is greater than a conservative screening value(s). It should be noted that the conservative screening values used are the USEPA Maximum Contaminant Levels (MCLs) and MDEQ Tier 1 TRG unrestricted screening values. Contaminants eliminated from further evaluation in the HHRA are assumed to present minimal risks to potential human receptors. COPCs that showed human health risks having a hazard index greater than 1 or a carcinogenic risk greater than 1×10^{-6} were selected as COCs. HHRA COCs identified in groundwater include TCE, trans-1,2-DCE, cis-1,2 DCE, VC, iron, manganese, and dioxin (TEQ).

10.3.2 Ecological Risk Assessment

Concentrations of a number of contaminants in Canal No. 1 sediment and surface water samples were greater than the conservative screening levels and were associated with potential unacceptable risk to ecological receptors. The detected contaminants, while possibly associated with Site 4, may also have been transported from other areas of NCBC Gulfport via storm water runoff through ditches that connect to Canal No. 1. When conservative assumptions used in the ERA are reevaluated and factors that affect potential exposures such as quality and size of the habitat and actual use of the site by modeled receptors are considered, the overall level of ecological risk associated with the cited contamination in Canal No. 1 is considered minimal.

10.4 CONSTRUCTION ACTIVITY

In late 2010, construction to implement the selected remedy began and is currently ongoing. Construction includes a low permeability cover system, a landfill gas collection system, and the lining of Canal No. 1.

Low Permeability Cover System – From bottom to top, the low permeability cover system included a select landfill material layer, geocomposite gas management layer, 18-inches of low permeability soil having a maximum hydraulic conductivity of 1×10^{-5} centimeters per second (i.e., “infiltration layer”), and a 6-inch thick topsoil layer (i.e., “erosion layer”). The low permeability cover system construction includes grading and consolidating removed Canal No. 1 sediment beneath the low permeability cover system footprint.

Landfill Gas Collection System – The gas management system consists of a geocomposite gas management layer located beneath the low permeability cover system, a gas collection trench, and passive gas vents. The geocomposite gas management layer terminates in the landfill gas collection trench located at the high point of the cover system (i.e., eastern limit). Landfill gas is discharged to the atmosphere via passive gas vents. Gas probes are located outside the limits of the low permeability cover system to detect methane gas that may be migrating laterally from the landfill.

Canal No. 1 Lining – The Canal No. 1 lining consists of a riprap surfaced low permeability cover system along the western limit of the low permeability cover system (i.e. eastern bank of Canal No. 1) and riprap surfacing on the bottom of Canal No. 1. Lining of Canal No. 1 was preceded by removal of the sediment (i.e., fine-grained organic muck) located in the portion of Canal No. 1 adjacent to Site 4 and removal of the carbon beds that were placed to remediate seeps.

10.5 CONCEPTUAL SITE MODEL

A summary of the Conceptual Site Model (CSM) based on current site conditions are shown on Figure 10-2. The following text describes the current CSM.

10.5.1 Geology and Hydrogeology

Surface and shallow subsurface soils are primarily gray and brown sand to sandy clay with varying amounts of gravel and minor clay horizons. The uppermost 2 feet in most areas is fill material used in the construction of the golf course. Large pieces of concrete and other landfill material are present from 4 to 8 feet below ground surface (bgs). Below the fill material, typical lithologies are light brown and gray fine sands and silty fine sands found to depths of approximately 24 feet bgs. The top of the thin gray silty clay

and clay layer is encountered at depths of approximately 20 to 24 feet bgs, depending on site topography. This clay layer is persistent across the site. Below the first clay layer, gray silty sand and sand lithologies are present to depths of 40 to 45 feet bgs. At approximately 45 feet bgs, thick green-gray clayey silt layer is encountered. This layer is persistent across the site and ranges from 10 to 50 feet thick. Depending on the types of contaminants detected, this layer may represent an aquitard that separates the shallow surficial aquifer from deeper water bearing units.

The groundwater at Site 4 was encountered in the shallow subsurface, typically within 15 to 22 feet of ground surface during previous investigations. The surficial aquifer consists of fine-grained silty sand and is unconfined. The surficial aquifer extends to approximately 45 feet bgs at Site 4 and is separated from the primary drinking water aquifer (Miocene) by a much more plastic gray silty/sandy clay layer. Groundwater flow in the shallow groundwater interval is to the northwest. The estimated average groundwater velocity for the shallow wells at Site 4 was calculated at 1.7 feet per day. The estimated average groundwater velocity for the deep wells at Site 4 was calculated at 0.06 feet per day (Tetra Tech, 2009a). Groundwater from the shallow surficial aquifer and surface water from Canal No. 1 are closely linked at Site 4, and groundwater can potentially discharge to Canal No. 1 during most of the year. Groundwater seeps on the south bank of Canal No. 1 have historically been present during wetter parts of the year. Potentiometric surface developed for the RI are provided as Figure 10-3 and Figure 10-4, respectively. Surface water features are provided in Figure 10-5. The geologic cross section developed for the RI are provided as Figure 10-6.

10.5.2 Sources and Potential Contaminants

The primary source of contamination at Site 4 is the refuse that was disposed of when the site was used as an active landfill. The majority of the waste disposed at the site was solid waste, such as construction debris and general refuse. According to previous investigations, nearly 16,000 tons of solid waste, including building and infrastructure debris from damage due to Hurricane Camille (1969), were disposed at the landfill. Additionally, as much as 20,000 gallons of waste liquids were disposed at the site, including fuels, oils, solvents, paints, and paint thinners. After waste disposal activities ceased, the site was covered with 4 to 6 feet of fine- to medium-grained sand.

During the RI, the VOCs TCE, trans-1,2-DCE, cis-1,2 DCE, and VC; the metals of iron and manganese; and dioxins/furans congeners (TEQ) were identified in the HHRA as COCs.

10.5.3 Migration Pathways and Potential Receptors

Because waste material is present in the subsurface, subsurface soil may be contaminated. Previous investigations have identified that groundwater that comes in contact with the waste material have

become contaminated. Sediments in Canal No. 1 have been removed and the canal was lined to prevent groundwater seepage to surface water. The site is currently being covered with an engineered landfill cap designed to limit the infiltration of storm water into the subsurface during precipitation events. Contaminated groundwater has migrated horizontally to the west/southwest.

The NCBC Gulfport surface water runoff is collected and transported to several outfalls via a network of channels (canals). These channels collect surface water runoff from six drainage areas throughout NCBC Gulfport. Site 4 is located in Drainage Area 5. The drainage patterns of Drainage Area 5 are presented on Figure 10-5. Flow throughout the majority of the on-base drainage channels is perennial. The upgradient drainage channels are dry for part of the year.

Potential current and future human receptors at Site 4 include people employed at the site, trespassers, maintenance workers, and recreational site users who could potentially interact with contaminated media. Future land use is limited by the current LUCs that prohibit residential or agricultural reuse of the site, restrict excavation/disturbance of soils, and restrict extraction of groundwater from the surficial aquifer. Future human receptors could be exposed to groundwater (via dermal contact, ingestion, inhalation, or vapor intrusion) although unlikely because of the current LUCs at Site 4.

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Legend

- Land Use Control Boundary
- Groundwater Plume
- Landfill Boundary
- Landfill Cap Limit
- Sediment Removal Area



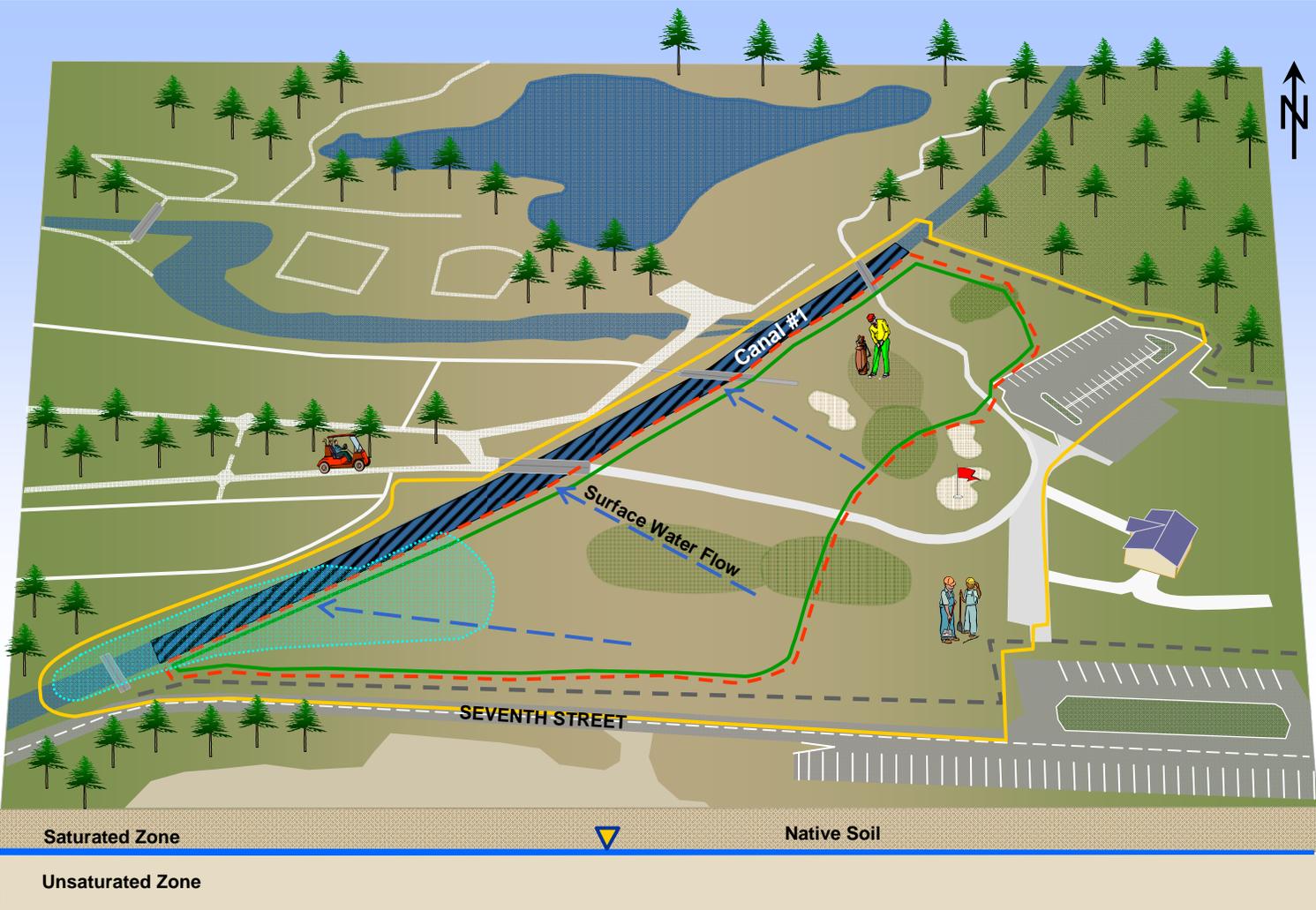
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COST/SCHEDULE-AREA	

SCALE
AS NOTED



**SITE LAYOUT
 SITE 4 GOLF COURSE LANDFILL
 NCBC GULFPORT
 GULFPORT, MISSISSIPPI**

CONTRACT NUMBER CTO 0068	
APPROVED BY	DATE
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FIGURE NO.	REV
FIGURE 10-1	0



LEGEND

- Water Table
- Landfill Boundary
- Landfill Cap Limit
- Fence
- Land Use Control Boundary
- Surface Water Flow
- Plume
- Local Trees

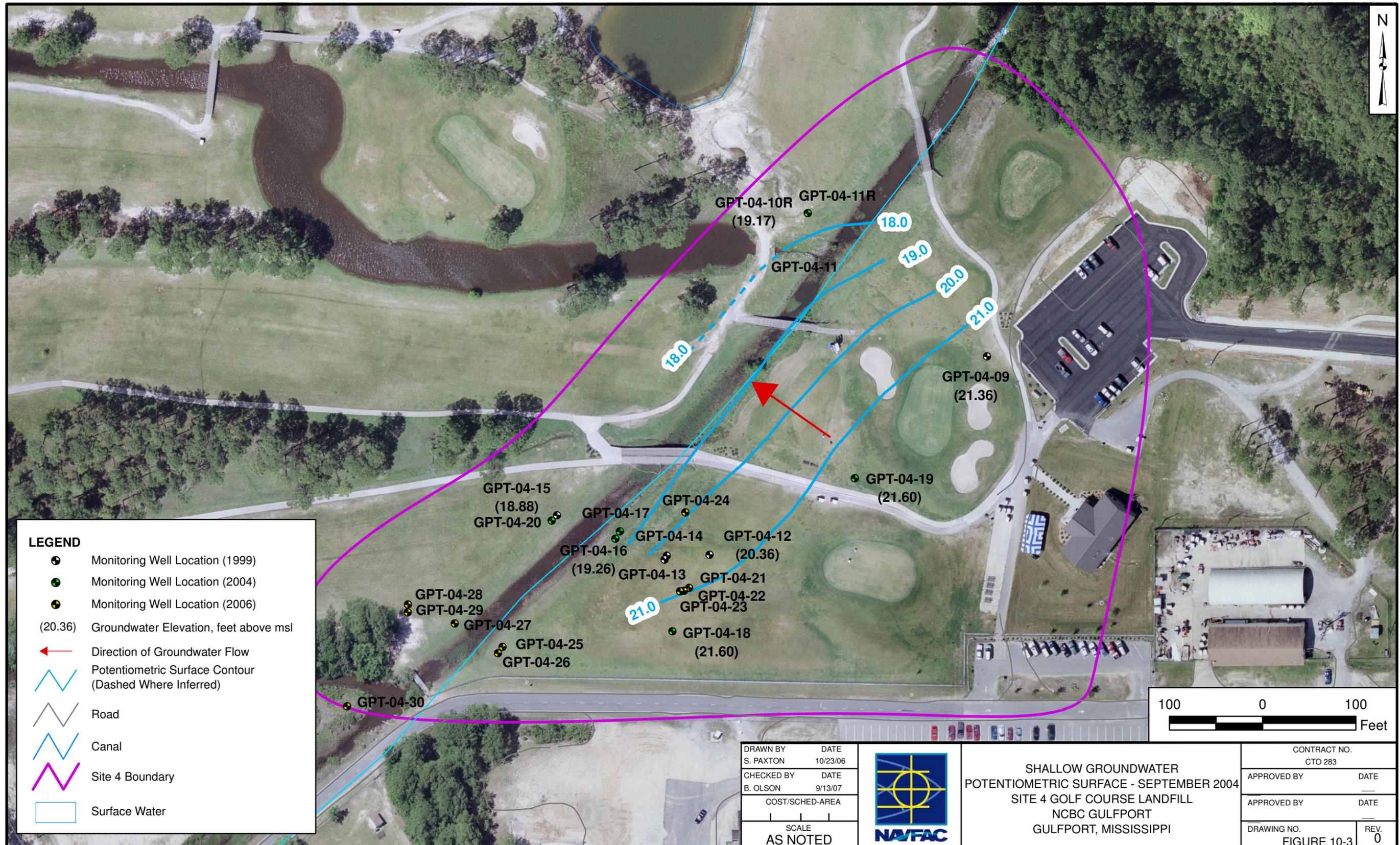
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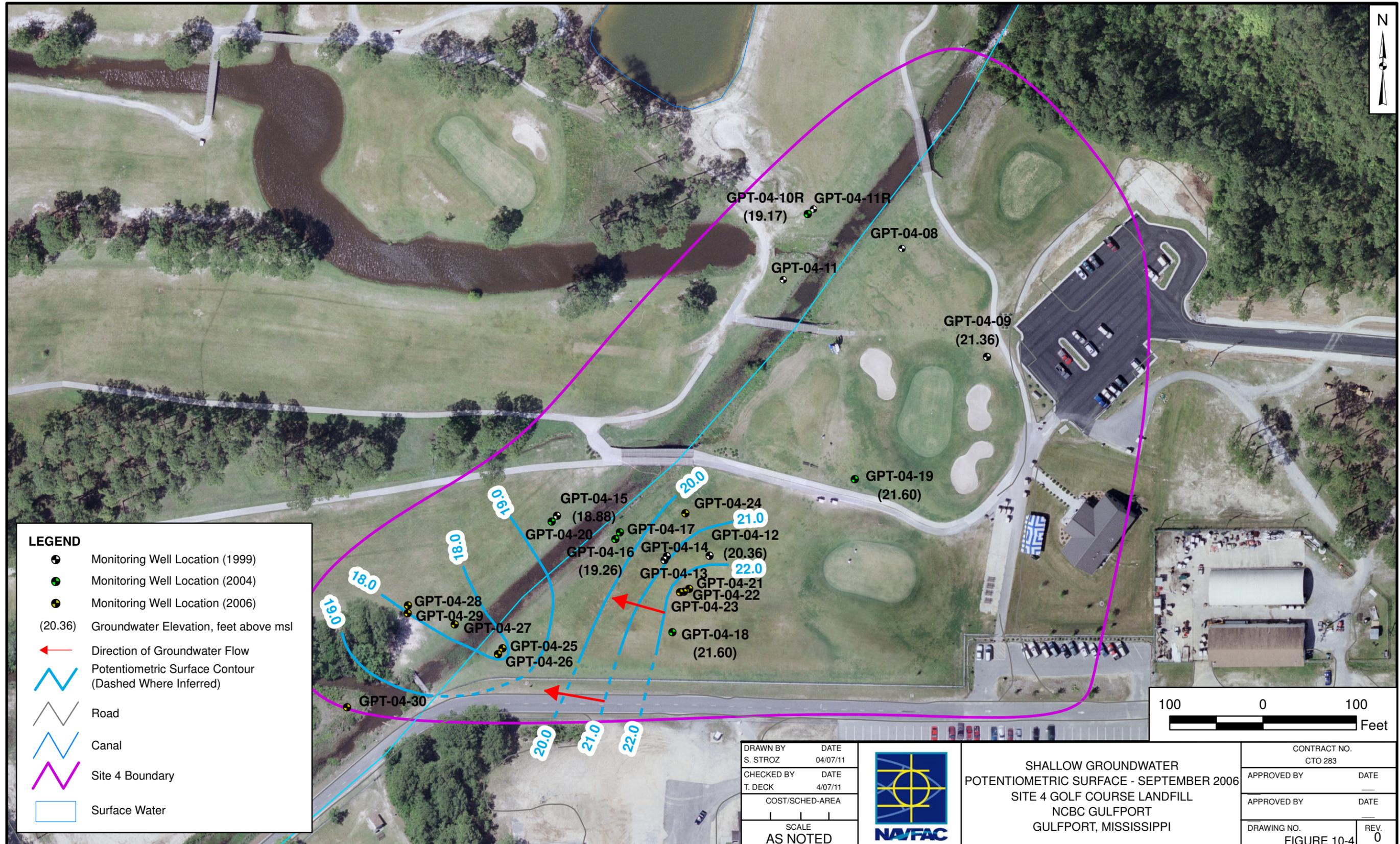
CONCEPTUAL SITE MODEL
 SITE 4, NCBC GULFPORT
 GULFPORT, MISSISSIPPI

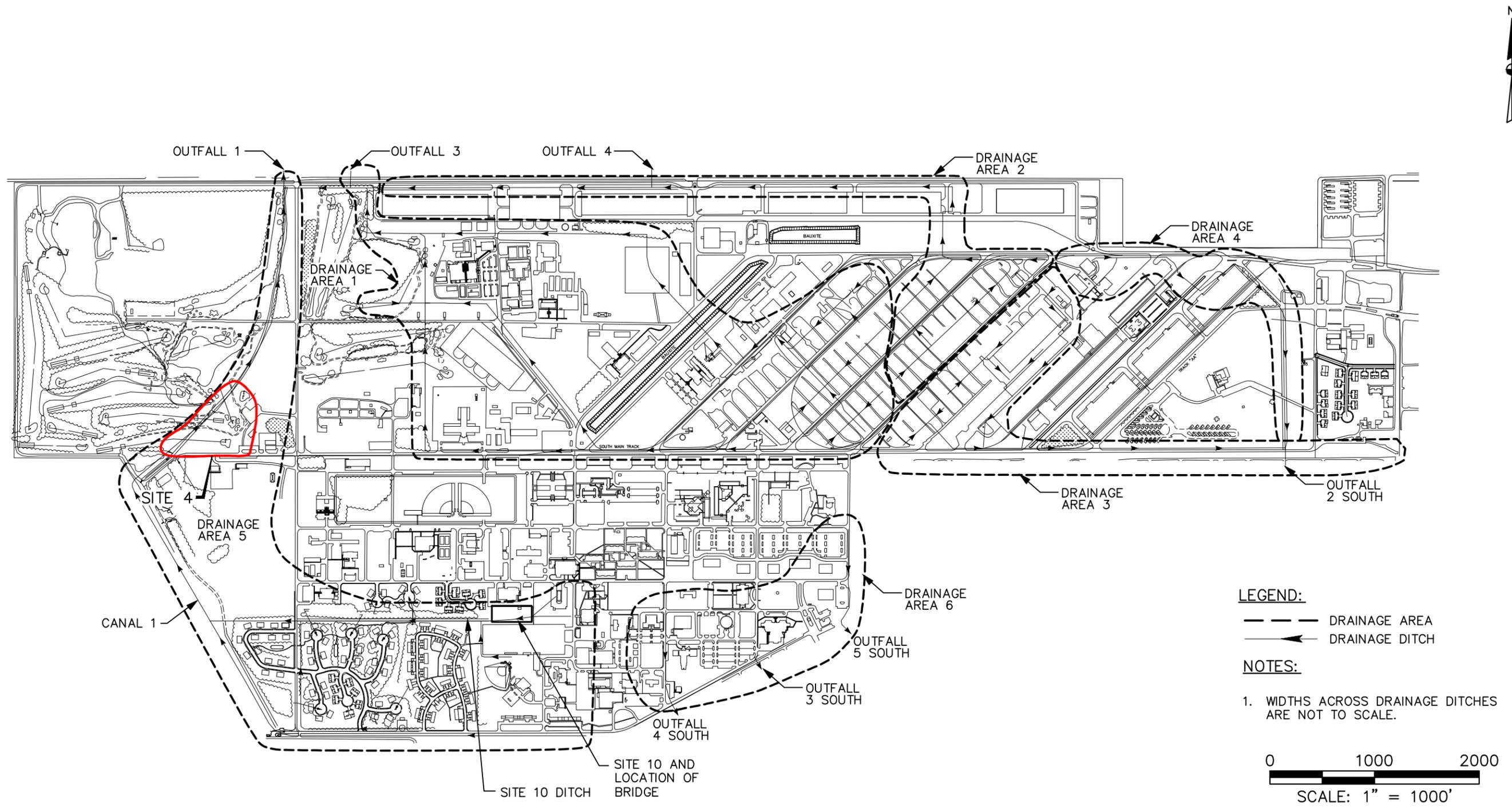
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FIGURE 10-2	

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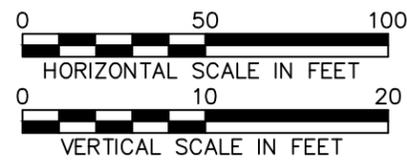
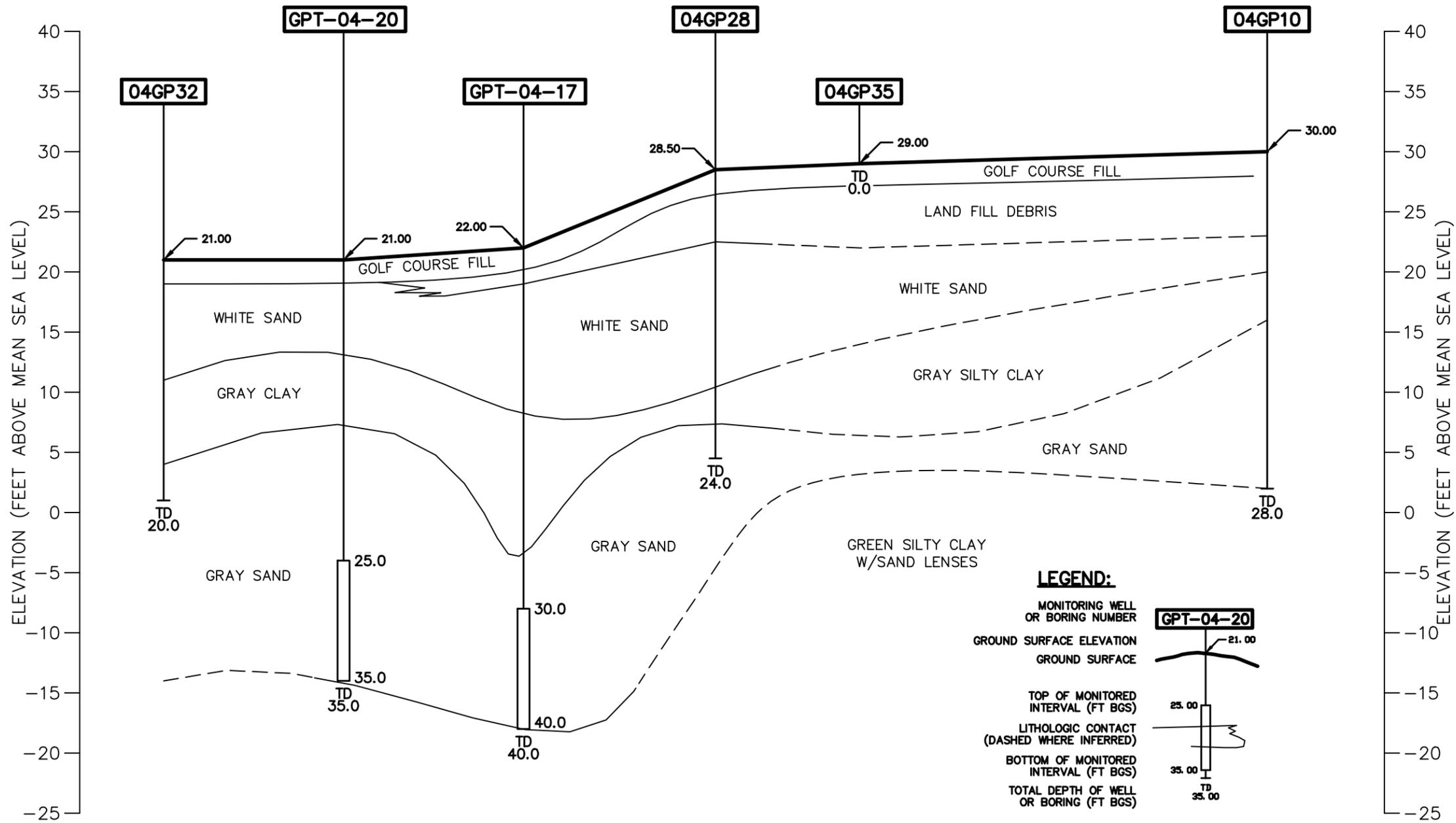
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SURFACE WATER FEATURES
SITE 4 - GOLF COURSE LANDFILL
NCBC GULFPORT
GULFPORT, MISSISSIPPI

CONTRACT NO. 3334	
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GEOLOGICAL CROSS SECTION
 SITE 4
 NCBC GULFPORT
 GULFPORT, MISSISSIPPI

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

11.1 PROBLEM STATEMENT

The primary objective of this investigation is to evaluate the extent of the existing chlorinated VOCs groundwater plume and to assess the favorability of geochemical conditions for natural attenuation. A Site Conditions Memorandum will document the evaluation of the chlorinated VOCs groundwater plume. Based on the results of the investigation, the Navy may determine if additional treatment is warranted to accelerate remediation times based on the significance of the PSL exceedance(s).

11.2 INFORMATION INPUTS

To meet the study goals of the investigation, the physical and chemical data to be collected at Sites 4 are described below:

1. Groundwater Quality Data: Groundwater quality parameters of dissolved oxygen, conductivity, pH, temperature, turbidity, and oxidation-reduction potential (ORP) data are needed to ensure groundwater samples are representative of the aquifer being investigated.
2. Groundwater Level Measurements: Water level measurements are needed to determine groundwater flow direction and gradients.
3. Survey Data: Survey data are needed for newly installed monitoring wells (if applicable).
4. Chemical Analysis: Groundwater chemical data are needed to evaluate the current conditions of the chlorinated VOCs groundwater plume. The list of chemical analytical groups and individual target analytes within each group is presented in Worksheet #15. The sampling rationale and methods are presented in Worksheet #17 and Worksheet #18, and the analytical methods are presented in Worksheet #19. The selected COCs represent those analytes that are associated with historical site operations that exceeded risk-based screening levels, as identified in the CSM in Section 10.5. COCs are identified as TCE, trans-1,2-DCE, cis-1,2 DCE, VC, iron, manganese, and dioxins/furans congeners (TEQ).
5. Natural Attenuation: Groundwater natural attenuation data are needed to evaluate the favorability of geochemical conditions for reductive dechlorination. Natural attenuation parameters for this study are ammonia, orthophosphate, sulfate, sulfide, chloride, dissolved gases [methane, ethane, ethane (MEE), and hydrogen], volatile fatty acids, and total organic carbon (TOC).

6. Reducing Bacteria and Enzymes: Groundwater chlorinated VOCs-reducing bacteria and enzymes data are needed to evaluate the efficacy of natural attenuation of the chlorinated VOCs by reductive dechlorination. Reducing bacteria and enzyme parameters for this study are BAV1 VC Reductase (R-Dase), Dehalococcoides, TCE R-Dase, and VC R-Dase.

Project Screening Levels

Concentrations of COCs in groundwater will be compared against Project Screening Levels (PSLs). For this investigation the screening values, which are also known as the PSLs, are listed below:

- USEPA National Primary Drinking Water Regulations, Maximum Contaminant Levels (FED MCL) (USEPA, 2009).
- MDEQ Tier 1 Target Remedial Goals for Groundwater (MS TIER 1 TRG), Appendix A of the Final Governing Brownfields Voluntary Cleanup and Redevelopment in Mississippi (MDEQ, 2002).

To conduct comparisons of site data to the PSLs for groundwater, the selected laboratory should be able to achieve Limits of Quantitation (LOQs) that are low enough to measure the analytical constituents at concentrations less than the applicable PSLs. In some cases, this may not be achievable. The Partnering Team will accept the laboratory analytical results between the Detection Limit (DL) and the LOQ if the results are "J" qualified. J-flagged data will be accepted to achieve project goals when the PSL is between the LOQ and the DL.

Prior to calculating a TEQ value for dioxins/furans by using a toxic equivalent factor (TEF) for each congener to sum the toxicity represented by the dioxins/furans group as a whole, non-detect results will be assigned a value of one-half the estimated detection limit (EDL). Rejected values ("R" flagged during data validation) will be eliminated from further consideration because they are regarded as unreliable. Estimated and biased values (flagged "J") will be used at the reported value with the realization that some uncertainty is associated with the reported numerical result. When duplicate sample pairs are reported, the average of the duplicate pair will be used for the statistical calculations. Any data limitations and the impact on data usability will be documented in the Site Conditions Memorandum.

11.3 STUDY AREA BOUNDARIES

The horizontal boundary the groundwater investigation is defined by the horizontal extent of the chlorinated VOC groundwater plume at concentrations above the PSL. The chlorinated VOC groundwater plume is located in the southwest of portion of Site 4 (Figure 10-1).

The vertical boundary for the groundwater investigation is defined by the vertical extent of where the chlorinated VOCs groundwater plume exists at concentrations above the PSL, which is limited by the presence of the sandy clay layers between 22 and 30 feet bgs. Groundwater data will be collected from both the shallow groundwater table (typically less than 15 feet bgs) and deep groundwater data (greater than 15 feet bgs) to determine the actual vertical boundary.

COC concentrations are anticipated to be relatively unchanged (stable) over the course of time needed to conduct the environmental investigations and into the foreseeable future; therefore, no temporal constraints exist. Field activities are scheduled to commence in October 2011 and terminate in April 2012.

11.4 ANALYTIC APPROACH

This SAP was developed to ensure that the remedial action performed at Site 4, as identified in the Site 4 Decision Document (Tetra Tech, 2010) continue to be protective of human and ecological receptors. The analytic approach for this investigation includes decision rules (Figure 11-1) related to reevaluating the extent of the existing chlorinated VOCs groundwater plume beyond the presumptive remedy boundary and to determine the extent of contamination.

Groundwater Plume Evaluation

If COC concentrations surrounding the perimeter of the known chlorinated VOCs groundwater plume are less than the corresponding PSLs, then proceed to LTM in accordance with the Site 4 Decision Document. If any COC concentration at any location surrounding the perimeter of the known plume exceed a PSL, then continue to define the extent of contaminant migration, as necessary, by installing new monitoring wells downgradient from the well(s) where one or more COCs exceed the PSL and analyzing the groundwater for PSL exceedances. Once complete with the evaluation, the Navy will recommend to the Partnering Team if additional treatment is warranted to accelerate remediation times based on the significance of the PSL exceedance(s). Factors that will influence this recommendation include the magnitude of the PSL exceedance(s) and the type of chemical exhibiting an exceedance (e.g., the recommended treatment will be different for VOCs, metals, or dioxins/furans).

Natural Attenuation Evaluation

During this investigation, the geochemical conditions will be evaluated and compared to results obtained during the TS to determine if they continue favorable for reductive chlorination. Reducing

bacteria/enzymes and natural attenuation parameters will be used for this evaluation. Decisions based on additional treatment will be made by the Partnering Team.

If the geochemical conditions at Site 4 are favorable for reductive dechlorination to occur, then no additional treatment (nutrient injection) to accelerate natural attenuation will be required. If the geochemical conditions at Site 4 are not favorable for reductive dechlorination to occur, then the Navy will recommend to the Partnering Team if additional treatment (nutrient injection) is warranted to accelerate remediation times.

11.5 PERFORMANCE OR ACCEPTANCE CRITERIA

Because the biased sampling locations were strategically selected to ensure that any landfill-related contaminants are not migrating out of the area where the previously delineated chlorinated VOCs groundwater plume was contained, probability limits for false positive and false negative decision errors were not established. Simple comparisons of measured concentrations to PSLs are being used. The Partnering Team will use the measured results to determine whether the amount and type of data collected are sufficient to support the attainment of the project objectives. This will involve an evaluation of contaminant concentrations and an evaluation of uncertainty for contaminants that have PSLs that are less than the DLs to ensure that contaminants are likely to have been detected, if present. If data have been collected as planned and no data points are missing or rejected for quality reasons, the sampling event completeness will be considered satisfactory. If any data gaps are identified, including missing or rejected data, the Partnering Team will assess whether a claim of having obtained project objectives is reasonable. This assessment will depend on the number and type of identified data gaps; therefore, a more detailed strategy cannot be presented at this time. Stakeholders will be involved in rendering the final conclusion regarding adequacy of the data.

11.6 DATA COLLECTION PLAN

The groundwater sampling design, rationale, and locations are summarized in Worksheets #17 and #18. These worksheets identify which monitoring wells are to be sampled, the analyses that will be conducted for each sample, and the reasons for including each monitoring well in the monitoring plan.

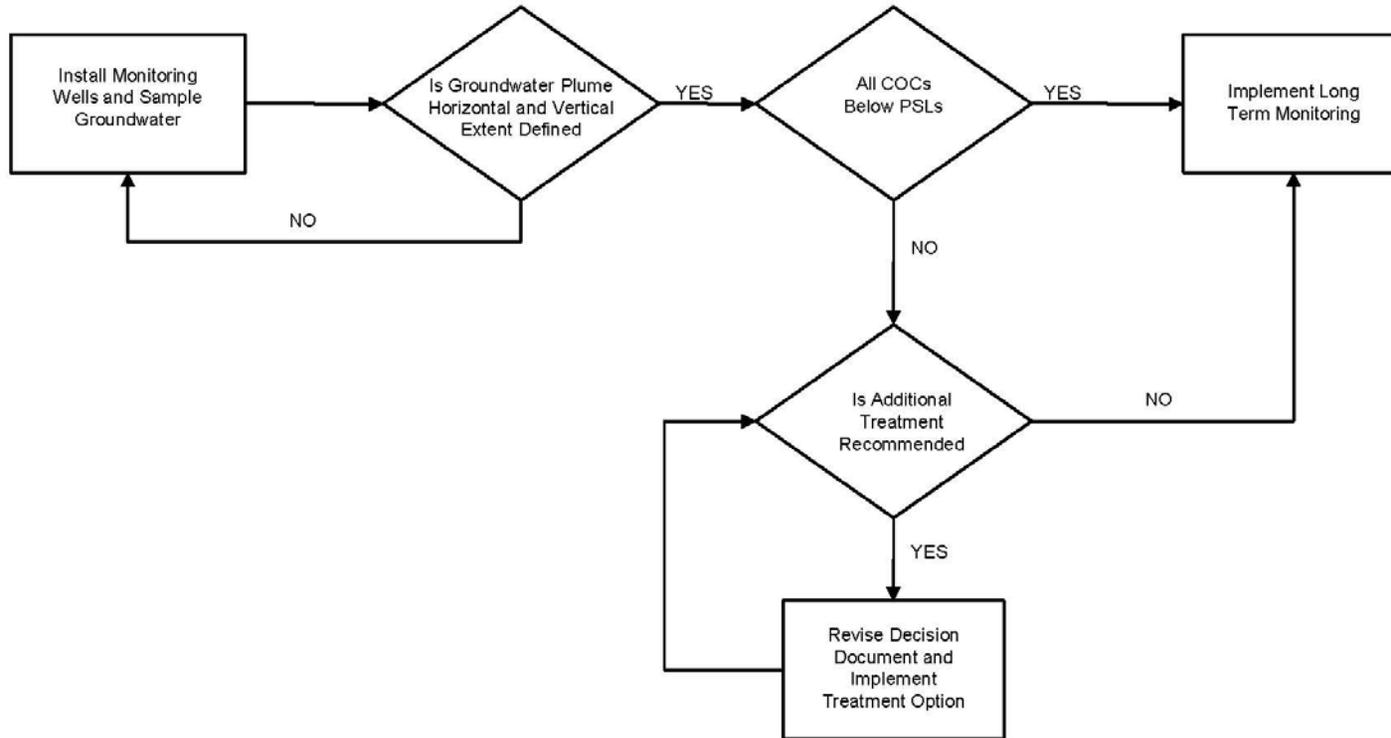


Figure 11-1
Conceptual Site Model Groundwater Decision Rules

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

QUALITY CONTROL (QC) SAMPLE	ANALYTICAL GROUP	FREQUENCY	DATA QUALITY INDICATORS (DQIs)	MEASUREMENT PERFORMANCE CRITERIA (MPC)	QC SAMPLE ASSESSES ERROR FOR SAMPLING (S), ANALYTICAL (A) OR BOTH (S&A)
Equipment Rinsate Blanks	All Fractions	One per 20 field samples per matrix per sampling equipment ¹ .	Bias/ Contamination	No analytes > ½ LOQ, except common laboratory contaminants, which must be < LOQ.	S&A
Trip Blanks	VOCs	One per cooler containing VOC samples.	Bias/ Contamination	No analytes > ½ LOQ, except common laboratory contaminants, which must be < LOQ.	S&A
Field Duplicate	All Fractions	One per 10 field samples collected.	Precision	Values > 5X LOQ: Relative Percent Difference (RPD) must be ≤30% ^{2,3} (aqueous).	S&A
Cooler Temperature Indicator	All Fractions	One per cooler.	Representativeness	Temperature must be less than or equal to 6 degrees Celsius (≤6°C), but not be frozen.	S

Notes:

- 1 Equipment rinsate blanks will be collected if non-dedicated submersible pumps or other equipment are used.
- 2 If duplicate values for non-metals are < 5x LOQ, the absolute difference should be < 2x LOQ.
- 3 If duplicate values for metals are < 5x LOQ, the absolute difference should be < 4x LOQ.

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
IAS	Originating Organization: Envirodyne Engineers, Inc. Report Title: <i>Initial Assessment Study for Naval Construction Battalion Center</i> Date: July 1, 1985	Originating Organization: Envirodyne Engineers, Inc. Data Types: Aerial Photos and Archive Search, Field Inspections and Interviews Data Collection Dates: February 1993 through October 1995	Historical information was used as reference.	None
Report	Originating Organization: Tetra Tech Report Title: <i>Treatability Study Memorandum Site 4 – Golf Course Landfill</i> Date: June 11, 2007	Originating Organization: Tetra Tech Data Types: Evaluation of previous groundwater report, additional groundwater samples, and bioaugmentation data Data Collection Dates: 2007	Bioaugmentation data and analytical data will be used as reference.	The analytical data is not recent; therefore, it will only be used as reference.

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
Report	Originating Organization: Tetra Tech Report Title: <i>Feasibility Study for Site 4 – Golf Course Landfill</i> Date: November 13, 2009	Originating Organization: Tetra Tech Data Types: Evaluation of previous groundwater report, additional groundwater samples, geophysical survey, and remedial alternatives Data Collection Dates: 2009	Remedial alternatives, geophysical survey and analytical data will be used as reference.	The analytical data is not recent; therefore, it will only be used as reference.
Report	Originating Organization: Tetra Tech Report Title: <i>Remedial Investigation at Site 4 – Golf Course Landfill</i> Date: November 13, 2009	Originating Organization: Tetra Tech Data Types: Evaluation of previous groundwater report, additional groundwater samples, and geophysical survey Data Collection Dates: 2009	Geophysical survey and analytical data will be used as reference.	The analytical data is not recent; therefore, it will only be used as reference.

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

The field tasks associated with the Site 4 sampling event is summarized below along with short descriptions of these tasks.

- Mobilization/Demobilization
- Health and Safety Training
- Utility Clearance
- Monitoring Well Installation and Development
- Monitoring Equipment Calibration
- Water Level Measurements
- Groundwater Sampling
- Field Decontamination Procedure
- Investigation Derived Waste (IDW) Management
- Documentation and Records
- Data Packages
- Data Review Tasks

Mobilization and Demobilization

Mobilization shall consist of the delivery of equipment, materials, and supplies to the site; the complete assembly in satisfactory working order of such equipment at the site; and the satisfactory storage at the site of such materials and supplies. Tetra Tech FOL will coordinate with the Base POC to identify locations for the storage of equipment and supplies.

Demobilization shall consist of the prompt and timely removal of equipment, materials, and supplies from the site following completion of the work. Final demobilization includes the cleanup and removal of waste generated during the conduction of the investigation.

Health and Safety Training

Site-specific Health and Safety Training per the Site-Specific HASP will be provided to Tetra Tech field staff and subcontractors as part of the site mobilization. The Tetra Tech FOL will check each site worker for proper health and safety and medical monitoring information and maintain on file.

Utility Clearance

Prior to the commencement of any intrusive activities, Tetra Tech and/or the drilling contractor will coordinate with Mississippi One-Call for utilities location. Mississippi One-Call will identify and mark-out utilities that may be present within the soil sampling locations. Utility clearance will be conducted as described in Tetra Tech Standard Operating Procedure (SOP) HS-1.0 (Appendix B).

Additionally, NCBC requires that a NCBC excavation permit be prepared and submitted to NCBC Gulfport Public Works two weeks in advance of field activities. Formal approval (e.g. signed form) will be obtained by the FOL prior to beginning intrusive fieldwork. The excavation permit is provided as Appendix C.

Monitoring Well Installation and Development

If it is determined that the contaminant plume has migrated and that additional downgradient wells must be installed to define the extent of migration, then this step will be completed. An FTMR will be prepared and submitted to identify the location(s) of the new well(s). Well installation will be completed at the locations specified in the FTMR, and in accordance with Tetra Tech SOP SA-2.5 and GH-2.8 (Appendix B). Prior to sampling, the new wells will be developed to remove fine-grained materials. Well development procedures are described in Tetra Tech SOP GH-2.8 (Appendix B).

Monitoring Equipment Calibration

These procedures are described in Worksheet #22.

Water Level Measurements

One synoptic round of water level measurements will be conducted at the site as part of each groundwater sampling event to provide information regarding groundwater flow patterns and gradients. Water level measurements will be completed within the shortest time possible on the same day, and no sooner than 24 hours after a significant precipitation event to minimize the precipitation effects on the data sets. Water level measurements will be recorded to the nearest 0.01 foot and referenced to a top of casing notch, or if a notch is absent, to the north side of the top of the well casing. Wells in the proximity of the investigation area with the same screened interval will be gauged. Water levels will be recorded on a Tetra Tech water level form. The measurement instrument will be decontaminated prior to conducting the measurement event and between each monitoring well. Water level measurements will be conducted as described in Tetra Tech SOP GH-1.2 (Appendix B).

Groundwater Sampling

Groundwater samples will be collected using low-flow purging techniques (discharge rate of less than 1 liter per minute) with a peristaltic pump using Teflon tubing dedicated to each well. When a well is developed for sampling, a water quality meter will be used to monitor pH, ORP, dissolved oxygen, turbidity, and conductivity. Groundwater samples will be collected using the procedures specified in Tetra Tech SOP SA-1.1 and SA-1.6 (Appendix B). Samples will be identified as described in Tetra Tech SOP CT-04 (Appendix B). Worksheets #17 and #18 specify the groundwater sample locations and analytes for this investigation, and Worksheet #23 specifies the analytical methods to be used.

Eight groundwater samples will be collected during the first sampling event. Based on results of the chemical data gathered during the first event, additional groundwater monitoring wells (not to exceed three new wells) will be installed in biased locations during a second sampling event.

Field Decontamination Procedure

Sample containers will be provided certified-clean from the analytical laboratories. Sampling equipment (e.g., non-disposable hand trowels, hand augers) will be decontaminated prior to and between sampling at each location. At each site, an abbreviated decontamination procedure consisting of a soapy water (laboratory-grade detergent) rinse followed by a deionized water rinse will be performed. Field decontamination will be conducted as described in Tetra Tech SOP SA-7.1 (Appendix B).

Investigation Derived Waste Management

It is anticipated that waste materials will be generated during the field investigation. IDW for Site 4 includes purge water and soil cuttings (if new wells are installed). These wastes must be disposed in such a manner that does not contribute to further environmental contamination or pose a threat to public health or safety. Tetra Tech SOP SA-7.1 (Appendix B) provides information on the handling of IDW. Drums for storage of IDW will be provided by NCBC Gulfport Public Works Division (PWD). Disposal of the IDW following receipt of the analytical data should be coordinated with PWD.

Documentation and Records

Field documentation will be performed in accordance with Tetra Tech SOP SA-6.3 (Appendix B). A summary of field activities will be properly recorded in a bound logbook with consecutively numbered pages that cannot be removed. Logbooks will be assigned to field personnel and will be stored in a secured area when not in use.

At a minimum, the following information will be recorded in the site logbook:

- Name of the person to whom the logbook is assigned.
- Project name.
- Project start date.
- Names and responsibilities of on-site project personnel including subcontractor personnel.
- Arrival/departure of site visitors.
- Arrival/departure of equipment.
- Sampling activities and sample log sheet references.
- Description of subcontractor activities.
- Sample pick-up information, including chain-of-custody numbers, air bill numbers, carrier, time, and date.
- Description of borehole or monitoring well installation activities and operations.
- Health and safety issues.
- Description of photographs including date, time, photographer, picture number, location, and compass direction of photograph.

Entries will be written in ink and no erasures will be made. If an incorrect entry is made, striking a single line through the incorrect information will make the correction; the person making the correction will initial and date the change. Boring logs, sampling forms, and other field forms will be used to document field activities.

Data Packages

Data packages will include receipt of analytical data packages from the fixed-base laboratory and generation of Tetra Tech data validation reports.

Data Review Tasks

The fixed-base laboratory will verify that samples listed on the chain-of-custody are analyzed in accordance with methods specified on the chain-of-custody form, the laboratory scope of work, and in this SAP. Data verification and validation will be performed by Tetra Tech as described in Worksheets #35 and #36. A data validation report will be produced for each Sample Delivery Group (SDG).

Field data records and validated data will be reviewed by Tetra Tech personnel to determine the usability of the data (see Worksheet #37). The outcome of this assessment will be conveyed to the Project Team

for agreement before the project report is finalized. Data limitations pertaining to Project Quality Objectives and PSLs will be identified, and corrective actions will be taken as necessary.

ADDITIONAL PROJECT-RELATED TASKS

Additional project-related tasks include:

- Analytical Tasks
- Data Generation Procedures
- Data Management
- Assessment and Oversight
- Data Review
- Project Reports

Analytical Tasks

Empirical and CFA are both a current Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accredited laboratory. Copies of the laboratory accreditation for Empirical and CFA can be found in Appendix B. Microseeps and Microbial Insights are not DoD ELAP accredited laboratories, but will only be used for screening analyses for natural attenuation parameters (including chlorinated VOC-reducing bacteria and enzymes). Analyses will be performed in accordance with the analytical methods identified in Worksheet #19. Empirical and CFA will perform chemical analyses following laboratory-specific SOPs (Worksheets #19 and #23) developed based on the analytical methods listed in Worksheets #19 and #30. Proprietary laboratory SOPs (SOPs identified in Worksheet #23) have been reviewed by the Tetra Tech Project Chemist and were found to be suitable for this project.

Results will be reported in each analytical data package and electronic data deliverable (EDD). This information will also be captured in the project database that will eventually be uploaded to the Naval Installation Restoration Information Solution (NIRIS).

The analytical data packages provided by Empirical and CFA will be in a Contract Laboratory Program (CLP)-like format and will be fully validatable and contain raw data, summary forms for sample and laboratory method blank data, and summary forms containing method-specific QC information [results, recoveries, relative percent differences (RPDs), relative standard deviations, and/or percent differences, etc.].

Data Generation Procedures

Project documentation and records include the following:

- Field sample collection and field measurement records, as described in Worksheets #27 and #29.
- Data assessment documents and records, as listed in Worksheet #29.

Data recording formats are described in Worksheet #27.

Data Management

Data management tasks, including the data handling, tracking, storage, archiving, retrieval, and security processes, are addressed in Worksheet #29.

Assessment and Oversight

Refer to Worksheet #32 for assessment findings and corrective actions and to Worksheet #33 for QA Management Reports.

Data Review

Data verification is described in Worksheet #34, data validation is described in Worksheets #35 and #36, and the usability assessment is described in Worksheet #37.

Project Reports

A Draft Groundwater Evaluation Report will be prepared and submitted to the Navy and regulators (i.e., the Partnering Team) for review. The report will include a summary of the work performed in the approved SAP, field modifications as documented by the Tetra Tech FOL, summary and analysis of the analytical results, updated CSMs, and conclusions and/or recommendations.

Tetra Tech will respond to comments received on the draft report. The final version of the report will be submitted in hardcopy and electronic format to the project stakeholders.

SAP Worksheet #15 – Reference Limits and Evaluation Table
 (UFP-QAPP Manual Section 2.8.1)

Natural attenuation Parameters of TOC, anions (chloride and sulfate), dissolved sulfide, orthophosphate, ammonia, volatile fatty acids, and dissolved gases; and Bacteria and Enzyme Parameters of *Dehalococcoides* and Functional Genes (TCE reductase, BAV1 VC reductase, and VC reductase) are being collected to evaluate the occurrence of natural attenuation. These target analytes are not included in this worksheet because there are not defined PSLs associated with these parameters.

Matrix: Groundwater

Analytical: VOCs

Analyte	CAS Number	PSL (ug/L)	PSL Reference ¹	PQLG (ug/L)	EMPIRICAL		
					LOQ (ug/L)	LOD (ug/L)	DL (ug/L)
CIS-1,2-DICHLOROETHENE	156-59-2	70	FED MCL	23	1.0	0.50	0.25
TRANS-1,2-DICHLOROETHENE	156-60-5	100	FED MCL	33	1.0	0.50	0.25
TRICHLOROETHENE	79-01-6	5	FED MCL	1.7	1.0	0.50	0.25
VINYL CHLORIDE	75-01-4	2	FED MCL	0.67	1.0	0.50	0.25

Notes:

CAS – Chemical Abstracts Service
 PQLG – Project Quantitation Limit Goal
 µg/L = microgram per liter

¹ Groundwater PSL references: FED MCL = USEPA Maximum Contaminant Levels, National Primary Drinking Water Regulations (5/2009)

Matrix: Groundwater

Analytical: Metals

Analyte	CAS Number	PSL (ug/L)	PSL Reference ¹	PQLG (ug/L)	EMPIRICAL		
					LOQ (ug/L)	LOD (ug/L)	DL (ug/L)
IRON	7439-89-6	11,000	MS TIER 1 TRG	3,700	25	15	7.5
MANGANESE	7439-96-5	730	MS TIER 1 TRG	240	3.75	1.5	0.75

Notes:

¹Groundwater PSL references: MS TIER 1 TRG = MDEQ Tier 1 TRGs, Groundwater (2/2002)

Matrix: Groundwater
Analytical: Dioxins/Furans

ANALYTE	CAS NUMBER	PSL (ug/L)	PSL REFERENCE ¹	PQLGs (ug/L)	CFA		
					LOQ (ug/L)	LOD (ug/L)	EDL (ug/L)
1,2,3,4,6,7,8-HPCDD	35822-46-9	0.0000446	MS TIER 1 TRG	0.000015	0.000015	0.00005	0.0000333
1,2,3,4,6,7,8-HPCDF	67562-39-4	0.0000446	MS TIER 1 TRG	0.000015	0.000015	0.00005	0.0000333
1,2,3,4,7,8,9-HPCDF	55673-89-7	0.0000446	MS TIER 1 TRG	0.000015	0.000015	0.00005	0.0000333
1,2,3,4,7,8-HXCDD	39227-28-6	0.00000446	MS TIER 1 TRG	0.0000015	0.0000015	0.00005	0.0000333
1,2,3,4,7,8-HXCDF	70648-26-9	0.00000446	MS TIER 1 TRG	0.0000015	0.0000015	0.00005	0.0000333
1,2,3,6,7,8-HXCDD	57653-85-7	0.0000108	MS TIER 1 TRG	0.0000036	0.0000036	0.00005	0.0000333
1,2,3,6,7,8-HXCDF	57117-44-9	0.00000446	MS TIER 1 TRG	0.0000015	0.0000015	0.00005	0.0000333
1,2,3,7,8,9-HXCDD	19408-74-3	0.0000108	MS TIER 1 TRG	0.0000036	0.0000036	0.00005	0.0000333
1,2,3,7,8,9-HXCDF	72918-21-9	0.00000446	MS TIER 1 TRG	0.0000015	0.0000015	0.00005	0.0000333
1,2,3,7,8-PECDD	40321-76-4	0.000000893	MS TIER 1 TRG	0.0000003	0.0000003	0.00005	0.0000333
1,2,3,7,8-PECDF	57117-41-6	0.00000893	MS TIER 1 TRG	0.000003	0.000003	0.00005	0.0000333
2,3,4,6,7,8-HXCDF	60851-34-5	0.00000446	MS TIER 1 TRG	0.0000015	0.0000015	0.00005	0.0000333
2,3,4,7,8-PECDF	57117-31-4	0.000000893	MS TIER 1 TRG	0.0000003	0.0000003	0.00005	0.0000333
2,3,7,8-TCDD	1746-01-6	0.00003	MS TIER 1 TRG	0.00001	0.00001	0.00001	0.00000667
2,3,7,8-TCDF	51207-31-9	0.00000446	MS TIER 1 TRG	0.0000015	0.0000015	0.00001	0.00000667
OCDD	3268-87-9	0.000446	MS TIER 1 TRG	0.00015	0.00015	0.0001	0.0000667
OCDF	39001-02-0	0.000446	MS TIER 1 TRG	0.00015	0.00015	0.0001	0.0000667
TOTAL HPCDD	37871-00-4	---	---	---	NA	0.00005	0.0000333
TOTAL HPCDF	38998-75-3	---	---	---	NA	0.00005	0.0000333
TOTAL HXCDD	34465-46-8	---	---	---	NA	0.00005	0.0000333
TOTAL HXCDF	55684-94-1	---	---	---	NA	0.00005	0.0000333
TOTAL PECDD	36088-22-9	---	---	---	NA	0.00005	0.0000333
TOTAL PECDF	30402-15-4	---	---	---	NA	0.00005	0.0000333
TOTAL TCDD	41903-57-5	---	---	---	NA	0.00001	0.00000667
TOTAL TCDF	55722-27-5	---	---	---	NA	0.00001	0.00000667

Notes:

Bolded compounds indicate PSL values that are less than the laboratory LOQ. However, the Limit of Detection (LOD) is sufficiently low to meet the PSL and for the intended data use.

Bolded and Shaded compounds have LOQs and LODs that do not meet the PSL. The approach for risk assessment and decision making is described in Worksheet #11, Sections 11.2 and 11.4. Any uncertainties introduced by LODs or LOQs that are greater than PSLs will be described in the Site Conditions Memorandum. The DL is provided for completeness of evaluation.

¹ Groundwater screening references: MS TIER 1 TRG = MDEQ Tier 1 TRGs, Groundwater (2/2002)

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

ACTIVITIES	ORGANIZATION	DATES (MM/DD/YY)		DELIVERABLE ACTUAL SUBMITTAL
		ANTICIPATED DATE(S) OF INITIATION	ANTICIPATED DATE OF COMPLETION	
Prepare Rough Draft SAP Work Plan & Appendices	Tetra Tech		06/01/11	
Submit Rough Draft SAP Work Plan & Appendices	Tetra Tech	06/01/11	06/01/11	
Navy Review	Navy	06/01/11	06/17/11	
Prepare Draft SAP Work Plan & Appendices	Tetra Tech	06/17/11	06/24/11	
Submit Draft SAP Work Plan & Appendices	Tetra Tech	06/24/11	06/24/11	
Regulator Review	MDEQ	06/24/11	07/24/11	
Receive Comments/Comment Resolution	Tetra Tech	07/24/11	08/01/11	
Prepare Final SAP Work Plan & Appendices	Tetra Tech	08/01/11	08/05/11	
Submit Final SAP Work Plan & Appendices	Tetra Tech	08/05/11	08/05/11	
Mobilization and Field Investigation	Tetra Tech	10/03/11	10/07/11	
Complete Field Investigation and Demobilization	Tetra Tech	10/07/11	10/07/11	
Laboratory Analysis	Empirical, CFA, Microseeps, and Microbial Insights	10/07/11	11/07/11	
Data Validation	Tetra Tech	11/07/11	12/07/11	
Database Entry	Tetra Tech	12/07/11	12/14/11	
Prepare Draft Site Conditions Memorandum	Tetra Tech	12/15/11	01/16/12	
Submit Draft Site Conditions Memorandum	Tetra Tech	01/16/12	01/16/12	
Navy Review	Navy	01/16/12	01/27/12	
Prepare Draft Final Site Conditions Memorandum	Tetra Tech	01/27/12	02/03/12	
Submit Draft Final Site Conditions Memorandum	Tetra Tech	02/03/12	02/03/12	
Regulator Review	MDEQ	02/03/12	03/05/12	
Receive Comments/Comment Resolution	Tetra Tech	03/05/12	03/05/12	
Prepare Final Site Conditions Memorandum	Tetra Tech	03/05/12	03/16/12	
Submit Final Site Conditions Memorandum	Tetra Tech	03/16/12	03/16/12	

Bold activities are deliverables.

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

The sampling activities to be conducted in support of the Site 4 groundwater evaluation are presented below, including the proposed sample locations, sampling methods, and a rationale for the sampling activities. The proposed sample locations are presented on Figure 17-1. Rationale for proposed sampling locations are presented in Table 17-1. The proposed groundwater sampling locations for Sites 4 were chosen based on the CSM, the current understanding of site-specific conditions, and the need to collect data that will help resolve the problem statement described in Worksheet #11.

Groundwater Sampling

Two semiannual rounds of groundwater water monitoring will be conducted in the area of the known chlorinated VOCs groundwater plume. Synoptic groundwater levels will be measured in each monitoring well to determine the groundwater flow direction. Groundwater samples will be analyzed for the site COCs of VOCs, metals, and dioxins/furans. Natural attenuation parameters will be collected to assess the favorability of geochemical conditions for reductive dechlorination. Natural attenuation parameters for this study are ammonia, orthophosphate, sulfate, sulfide, chloride, dissolved gases (MEE and hydrogen), volatile fatty acids, and TOC. Additionally, to determine the efficacy of natural attenuation, groundwater samples collected during the initial event will be analyzed for microbial analysis of chlorinated VOCs-reducing bacteria and enzymes (BAV1 VC R-Dase, Dhc, TCE R-Dase, and VC R-Dase). Field measured investigation parameters for groundwater will include dissolved oxygen, ORP, pH, conductivity, temperature, and turbidity will also be collected during both sampling events.

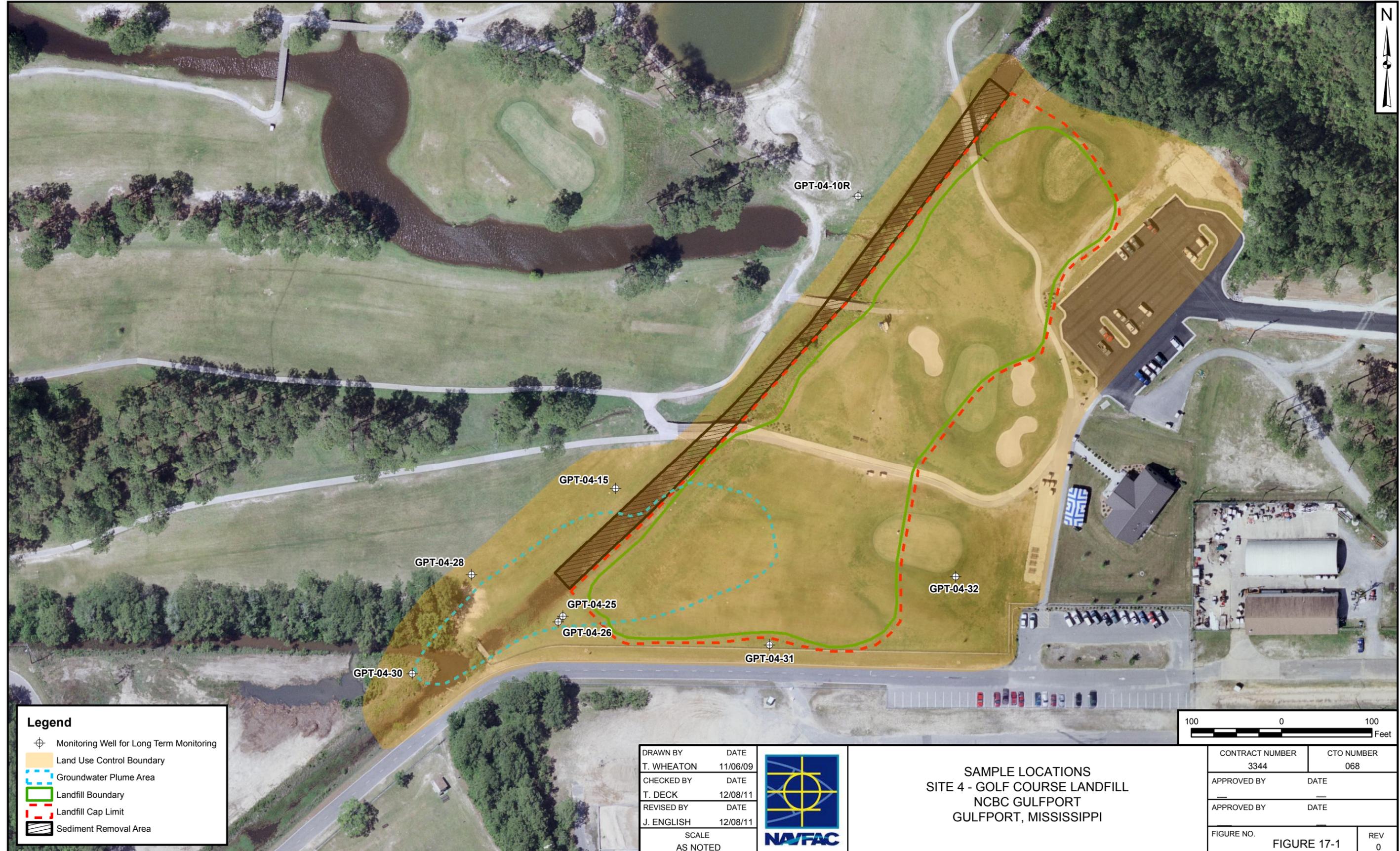
In order to evaluate the extent of the chlorinated VOCs groundwater plume at Site 4, it may be required that additional monitoring wells be installed. Up to three additional permanent monitoring wells will be installed during the second round of groundwater monitoring at locations downgradient of any monitoring well with COCs concentrations that exceed PSLs.

General Sampling and Analysis

Field QC samples will be collected as part of the investigation, including field duplicates, trip blanks, and equipment rinsate blanks. Worksheet #20 presents the field QC sample summary. Also, additional sample volume will be collected as necessary for the laboratory QC of matrix spike/ matrix spike duplicate (MS/MSD) analyses (for VOCs and dioxins/furans) and matrix spike/ matrix duplicate (MS/MD) analyses (for metals). The COCs associated with the groundwater samples that require field QC samples are presented in Worksheet #15. Groundwater samples for natural attenuation parameters and microbial analysis do not require field QC samples. The analytical method/SOPs are identified in Worksheet #23.

TABLE 17-1
SAMPLE LOCATIONS/RATIONALE
SITE 4
NCBC GULFPORT
GULFPORT, MISSISSIPPI

Location	Rationale	Analytes
GPT-04-10R	Upgradient/Side Gradient Well	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters
GPT-04-15	Side Gradient Well	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters
GPT-04-25	Within the Plume	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters
GPT-04-26	Within the Plume (Deep)	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters
GPT-04-28	Down Gradient Well	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters
GPT-04-30	Down Gradient Well	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters
GPT-04-31	Side Gradient Well	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters
GPT-04-32	Upgradient/Side Gradient Well	VOCs, Metals, Dioxins/Furans; Microbial Analysis (one event); Natural Attenuation Parameters

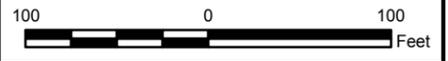


Legend	
	Monitoring Well for Long Term Monitoring
	Land Use Control Boundary
	Groundwater Plume Area
	Landfill Boundary
	Landfill Cap Limit
	Sediment Removal Area

DRAWN BY	DATE
T. WHEATON	11/06/09
CHECKED BY	DATE
T. DECK	12/08/11
REVISED BY	DATE
J. ENGLISH	12/08/11
SCALE	
AS NOTED	



SAMPLE LOCATIONS
 SITE 4 - GOLF COURSE LANDFILL
 NCBC GULFPORT
 GULFPORT, MISSISSIPPI



CONTRACT NUMBER	3344	CTO NUMBER	068
APPROVED BY	DATE	APPROVED BY	DATE
FIGURE NO.	FIGURE 17-1	REV	0

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

SAMPLING LOCATION/ IDENTIFICATION NUMBER	MATRIX	DEPTH (feet bgs)	ANALYTICAL GROUP	NUMBER OF SAMPLES	SAMPLING SOP REFERENCE
Groundwater (each sampling event)					
GPT-04-10R-YYYYMMDD	Groundwater	4-14	VOCs Metals Dioxins/Furans Microbial Analysis Natural Attenuation Parameters	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-15-YYYYMMDD	Groundwater	5-15	VOCs Metals Dioxins/Furans Microbial Analysis Natural Attenuation Parameters	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-25-YYYYMMDD	Groundwater	6-16	VOCs Metals Dioxins/Furans Microbial Analysis Natural Attenuation Parameters	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-26-YYYYMMDD	Groundwater	28-38	VOCs Metals Dioxins/Furans Microbial Analysis Natural Attenuation Parameters	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-28-YYYYMMDD	Groundwater	6-16	VOCs Metals Dioxins/Furans Microbial Analysis Natural Attenuation Parameters	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-30-YYYYMMDD	Groundwater	5-15	VOCs Metals Dioxins/Furans	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04

SAMPLING LOCATION/ IDENTIFICATION NUMBER	MATRIX	DEPTH (feet bgs)	ANALYTICAL GROUP	NUMBER OF SAMPLES	SAMPLING SOP REFERENCE
			Microbial Analysis Natural Attenuation Parameters		
GPT-04-31-YYYYMMDD	Groundwater	TBD	VOCs Metals Dioxins/Furans Microbial Analysis Natural Attenuation Parameters	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-32-YYYYMMDD	Groundwater	TBD	VOCs Metals Dioxins/Furans Microbial Analysis Natural Attenuation Parameters	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-##-YYYYMMDD (potential future well- second event)	Groundwater	TBD	TBD based on first round exceedances	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
Duplicates					
GPT-04-25-YYYYMMDD-01	Groundwater	TBD	VOCs Metals Dioxins/Furans	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04
GPT-04-XX-YYYYMMDD-02 (second sampling event)	Groundwater	TBD	TBD based on first round exceedances	1	Tetra Tech SOPs SA-1.1, SA-6.3, GH-1.2, GH-2.4, GH-2.8, and CT-04

Notes:

YYYYMMDD - date in year (YYYY) month (MM) day (DD)

XX – Location designation to be determined in the field/ Duplicates will be collected at locations where contamination is most likely.

- Potential second round well to be identified sequentially starting at 33.

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

MATRIX	ANALYTICAL GROUP	ANALYTICAL AND PREPARATION METHOD / SOP REFERENCE ⁽¹⁾	CONTAINERS (number, size, and type)	SAMPLE VOLUME (units)	PRESERVATION REQUIREMENTS (chemical, temperature, light protected)	MAXIMUM HOLDING TIME (preparation/ analysis)
Groundwater and aqueous QC samples	VOCs	SW-846 5030/8260B, Empirical SOP-202	Three 40-milliliter (mL) glass vials	5 mL	Hydrochloric acid (HCl) to pH<2; Cool to ≤6°C; no headspace	14 days to analysis
Groundwater and aqueous QC samples	Metals	SW-846 3010A/6010C, Empirical SOP-100/105	One 500-mL plastic bottle	50 mL	Nitric acid (HNO ₃) to pH <2; Cool to ≤6°C	180 days to analysis
Groundwater and aqueous QC samples	Dioxins/ Furans	SW-846 8290A, CFA SOP CF-OA-E-001, CF-OA-E-002	Two 1-liter (L) glass amber bottles	1,000 mL	Cool to ≤6°C	30 days for extraction, 45 days for analysis
Groundwater	TOC	SW-846 9060A, Empirical SOP-221	One 500-mL plastic bottle	250 mL	Sulfuric acid (H ₂ SO ₄) to pH <2; Cool to ≤6°C	28 days to analysis
Groundwater	Orthophosphate	SM 4500PM, Empirical SOP-165	One 500-mL plastic bottle	50 mL	Cool to ≤6°C	28 days to analysis
Groundwater	Anions (chloride and sulfate)	SW-846 9056A, Empirical SOP-145	One 500-mL plastic bottle	5 mL for each analyte	Cool to ≤6°C	Chloride/ Sulfate - 28 days to analysis

MATRIX	ANALYTICAL GROUP	ANALYTICAL AND PREPARATION METHOD / SOP REFERENCE ⁽¹⁾	CONTAINERS (number, size, and type)	SAMPLE VOLUME (units)	PRESERVATION REQUIREMENTS (chemical, temperature, light protected)	MAXIMUM HOLDING TIME (preparation/analysis)
Groundwater	Dissolved Sulfide	SM 4500S ²⁻ F, Empirical SOP-153	One 500-mL plastic bottle	200 mL	1 mL 2 Normal zinc acetate with NaOH to a pH >9; Cool to ≤6°C	7 days to analysis
Groundwater	Ammonia	SM 4500NH3D, Empirical SOP-167	One 500-mL plastic bottle	25 mL	H ₂ SO ₄ to pH <2; Cool to ≤6°C	14 days to analysis
Groundwater	Dehalococoides and reductase genes	Lab proprietary Methods, MI SOP DNA-qPCR and SOP DNA EXT	Laboratory filters (preferred)—1 per sample	1 L	Cool to ≤6°C	Ship day of collection; 24-48 hours to analysis
Groundwater	Dissolved gases (MEE)	RSK SOP 175, Microseeps SOP AM20 GAX	One –20 mL glass vial with stopper septa	20 mL	Cool to ≤6°C	14 days to analysis
Groundwater	Dissolved gases (hydrogen)	RSK SOP Microseeps SOP PM01/AM20 GAX	Two - 40 mL amber glass vials with dark grey septa	40 mL	Cool to ≤6°C	14 days to analysis
Groundwater	Volatile Fatty Acids	SW-846 9056, Microseeps SOP AM23 GAX	Three 40-mL glass vials	7 mL	Preserve with benzalkonium chloride; Cool to ≤6°C	14 days to analysis

¹ Laboratory SOPs are subject to revision and updates during duration of the project, the laboratory will use the most current revision of the SOP at the time of analysis.

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

MATRIX	ANALYTICAL GROUP	NUMBER OF SAMPLING LOCATIONS	NUMBER OF FIELD DUPLICATES	NUMBER OF MS/MSDS ¹	NUMBER OF FIELD BLANKS	NUMBER OF EQUIP. BLANKS	NUMBER OF VOA TRIP BLANKS	TOTAL NUMBER OF SAMPLES TO LAB
Groundwater (Round 1)	VOCs	8	1	1/1	0	1	1	11
	Metals	8	1	1/1	0	1	NA	10
	Dioxins/Furans	8	1	1/1	0	1	NA	10
	Natural Attenuation Parameters	8	NA	NA	NA	NA	NA	8
	Microbial Analysis	8	NA	NA	NA	NA	NA	8
Groundwater (Round 2) ²	VOCs	8 minimum 11 maximum	1	1/1	0	1	1	11 minimum 14 maximum
	Metals	8 minimum 11 maximum	1	1/1	0	1	NA	10 minimum 13 maximum
	Dioxins/Furans	0 minimum 11 maximum	1	1/1	0	1	NA	0 minimum 13 maximum
	NA Parameters	8 minimum 11 maximum	NA	NA	NA	NA	NA	8 minimum 11 maximum

Notes:

- 1 Although the MS/MSD is not typically considered a field QC and is not included in the total number of samples to the laboratory, it is included here because location determination is often established in the field.
- 2 Analytical groups for round two will be limited based on exceedances of the first round.

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	Title: <u>Sample Nomenclature</u> Effective Day: <u>March 9, 2009</u> Revision 2	Tetra Tech	NA	N	Contained in Appendix B.
CT-05	Title: <u>Database Record and Quality Assurance</u> Effective Day: <u>January 29, 2001</u> Revision 2	Tetra Tech	NA	N	Contained in Appendix B.
GH-1.2	Title: <u>Evaluation of Existing Monitoring Wells and Water Level Measurement</u> Effective Day: <u>September 2003</u> Revision 2	Tetra Tech	NA	N	Contained in Appendix B.
GH-2.5	Title: <u>Groundwater Contour Maps and Flow Determinations</u> Effective Day: <u>June 1999</u> Revision 1	Tetra Tech	Health and safety equipment, well drilling and installation equipment, hydrogeologic equipment, drive point installation tools	N	Contained in Appendix B.
GH-2.8	Title: <u>Groundwater Monitoring Well Installation</u> Effective Day: <u>September 2003</u> Revision 3	Tetra Tech	Health and safety equipment, well drilling and installation equipment, hydrogeologic equipment, drive point installation tools	N	Contained in Appendix B.
HS-1.0	Title: <u>Utility Locating and Excavation Clearance</u> Effective Day: <u>September 2003</u> Revision 2	Tetra Tech	Remote subsurface sensing, magnetometer, ground penetrating radar, etc.	N	Contained in Appendix B.
DV-01	Title: <u>Data Validation- Contract Laboratory Program (CLP) Organics for Solid and Aqueous Matrices</u> Effective Day: <u>January 28, 2009</u> Revision 3	Tetra Tech	NA	N	Contained in Appendix B.

REFERENCE NUMBER	TITLE, REVISION DATE AND/OR NUMBER	ORIGINATING ORGANIZATION OF SAMPLING SOP	EQUIPMENT TYPE	MODIFIED FOR PROJECT WORK? (Y/N)	COMMENTS
DV-03	Title: <u>Data Validation- CLP Inorganics for Solid and Aqueous Matrices</u> Effective Day: <u>February 2, 2009</u> <u>Revision 0</u>	Tetra Tech	NA	N	Contained in Appendix B.
DV-06	Title: Data Validation- Polychlorinated Dibenzodioxins and Polychlorinated Dibenzofurans for Solid and Aqueous Matrices Effective Day: <u>August 13, 2001</u> <u>Revision 0</u>	Tetra Tech	NA	N	Contained in Appendix B.
SA-1.1	Title: <u>Groundwater Sample Acquisition and Onsite Water Quality Testing</u> Effective Day: <u>April 7, 2008</u> <u>Revision 7</u>	Tetra Tech	NA	N	Contained in Appendix B.
SA-1.6	Title: <u>Natural Attenuation Parameter Collection</u> Effective Day: <u>September 2003</u> <u>Revision 1</u>	Tetra Tech	NA	N	Contained in Appendix B.
SA-2.5	Title: <u>Direct Push Technology (Geoprobe®/Hydropunch™)</u> Effective Day: <u>September, 2003</u> <u>Revision 3</u>	Tetra Tech	Geoprobe and sampling equipment	N	Contained in Appendix B.
SA-6.1	Title: <u>Non Radiological Sample Handling</u> Effective Day: <u>February 2004</u> <u>Revision 3</u>	Tetra Tech	NA	N	Contained in Appendix B.
SA-6.3	Title: <u>Field Decontamination</u> Effective Day: <u>March 9, 2009</u> <u>Revision 3</u>	Tetra Tech	NA	N	Contained in Appendix B.

REFERENCE NUMBER	TITLE, REVISION DATE AND/OR NUMBER	ORIGINATING ORGANIZATION OF SAMPLING SOP	EQUIPMENT TYPE	MODIFIED FOR PROJECT WORK? (Y/N)	COMMENTS
SA-7.1	Title: <u>Decontamination of Field Equipment</u> Effective Day: <u>January 28, 2009</u> Revision <u>6</u>	Tetra Tech	NA	N	Contained in Appendix B.

Note: Appendix B provides SOPs for activities to be conducted during the Site 4 investigation. SOPs have been marked through with a red "X" to indicate a section of the SOP that is not relevant and/or applicable to Site 4. Mark-ups have been initialed and dated.

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

FIELD EQUIPMENT	ACTIVITY¹	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	RESPONSIBLE PERSON	SOP REFERENCE²	COMMENTS
Water Quality Meter (YSI 600 Series or equivalent)	Visual Inspection	Daily	Manufacturer's guidance	Operator correction or replacement	Tetra Tech FOL or designee	GH-2.8, SA-1.1, Manufacturer's Guidance Manual	None
	Calibration/ Verification	Beginning and end of day					
Turbidity Meter (LaMotte 2020 or equivalent)	Visual Inspection	Daily	Manufacturer's guidance	Operator correction or replacement	Tetra Tech FOL or designee	GH-2.8, SA-1.1, Manufacturer's Guidance Manual	None
	Calibration/ Verification	Beginning and end of day					
Electronic Water Level Indicator	Visual Inspection	Daily	0.01 foot accuracy	Operator correction or replacement	Tetra Tech FOL or designee	GH-2.8, SA-1.1, Manufacturer's Guidance Manual	None
	Field checks as per manufacturer	Once upon receiving from vendor					

1 Activities may include calibration, verification, testing, maintenance, and/or inspection.

2 Specify the appropriate reference letter or number from the Project Sampling SOP References table (Worksheet #21).

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	Variance to QSM ¹ (Y/N)	Modified for Project Work? (Y/N)
Empirical SOP-100	Metals Digestion/ Preparation, Methods 3005A/ USEPA CLP ILMO 4.1 Aqueous, 3010A, 3030C, 3050B, USEPA CLP ILMO 4.1 (Soil/Sediment), 200.7, Standard Methods 3030C (Revision 21, 09/01/10)	Definitive	Groundwater and Aqueous Field QC Samples/ Metals Digestion	NA/ Preparation	Empirical	N	N
Empirical SOP-105	Metals by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) Technique, SW-846 Methods 6010B, 6010C, USEPA Method 200.7, Standard Methods 19 th Edition 2340B, USEPA CLP ILMO 4.1 (Revision 16, 04/11/10)	Definitive	Groundwater and Aqueous Field QC Samples/ Metals	Inductively Coupled Plasma (ICP) – Atomic Emission Spectroscopy (AES)	Empirical	N	N
Empirical SOP-145	Determination of Inorganic Anions in Water by Ion Chromatography using Dionex DX-500 Ion Chromatographs with Hydroxide Eluent and Dionex Column AS18, Method 300.0 Guidance (Revision 7, 03/25/10)	Definitive	Groundwater/ Anions	Ion Chromatography (IC)	Empirical	N	N
Empirical SOP-153	Sulfide Method 376.1 and Standard Methods SM4500S-F (19 th ED) (Titrametric, Iodine) with Sample Pretreatment to Remove Interfering Substances or to Concentrate the Sulfide (Revision 4, 09/07/10)	Definitive	Groundwater/ Dissolved Sulfide	Buret	Empirical	NA	N

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM ¹ (Y/N)	Modified for Project Work? (Y/N)
Empirical SOP-165	Phosphorous, Total and Ortho Standard Methods (20 th and 21 st Editions) Method SM4500P B5E and Method SM4500PE / USEPA Method 365.2 (Colorimetric, Ascorbic Acid, Single Reagent) (Revision 8, 09/07/10)	Definitive	Groundwater/ Orthophosphate	Spectrophotometer	Empirical	NA	N
Empirical SOP-167	Nitrogen Ammonia, Standard Methods 20 th Edition Method SM4500NH3D and SM4500NH3BD/ USEPA Method 350.2 (Potentiometric, Titrimetric, Distillation Procedure) (Revision 3, 12/22/08)	Definitive	Groundwater/ Ammonia	Ion Probe	Empirical	NA	N
Empirical SOP-202	GC/MS Volatiles using USEPA Method 624 and SW846 Method 8260B, Including Appendix IX Compounds (Revision 23, 09/09/10)	Definitive	Groundwater and Aqueous Field QC Samples/ VOCs	GC/MS	Empirical	N	N
Empirical SOP-221	Total Organic Carbon (TOC) by SM5310C, SW846 Method 9060 / 9060A and Lloyd Kahn Revision 09, 07/12/10)	Definitive	Groundwater / TOC	TOC Analyzer	Empirical	NA	N
Empirical SOP-QS10	<u>Laboratory Sample Receiving, Log In and Storage</u> (Revision 14, 09/07/10)	NA	Log-In	NA	Empirical	NA	N
Proprietary Microseeps SOP-AM20Gax	Analytical Method AM20Gax Standard Operating Procedure for the Analysis of Biodegradation Indicator Gases (Revision 11, 10/12/10)	Screening	Groundwater and Aqueous Field QC Samples/ Dissolved Gases (MEE) and Hydrogen (Bubblestrip Vapor)	Gas Chromatography/ Flame Ionization Detector (GC/FID) and Gas Chromatography/ Reduction Gas Detector (GC/RGD)	Microseeps	NA	N

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM ¹ (Y/N)	Modified for Project Work? (Y/N)
Proprietary Microseeps SOP-AM23G	Standard Operating Procedure for the Analyses of Low Level Volatile Fatty Acids by Ion Chromatography (Revision 5, 11/19/08)	Screening	Groundwater and Aqueous Field QC Samples/ Hydrogen Bubblestrip Vapor	Sampling Procedure	Microseeps	NA	N
CFA CF-OA-E-001	Standard Operating Procedure for Dioxin/ Furan/ PCB Congener Sample Processing (Revision 3, July 2010)	Definitive	Groundwater and Aqueous QC Samples/ Dioxins/Furans	NA/ Extraction	CFA	N	N
CFA CF-OA-E-002	Standard Operating Procedure for the Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDDs/PCDFs) by High Resolution Gas Chromatography/ High Resolution Mass Spectrometry (HRGC/HRMS) (EPA SW-846 Method 8290, EPA Method 1613B, EPA SW-846 Method 0023A) (Revision 8, December 2010)	Definitive	Groundwater and Aqueous QC Samples/ Dioxins/Furans	HRGC/HRMS	CFA	N	N
MI SOP-DNAEXT	Extraction of DNA from Environmental Samples (matrix-water, soil, biofilm, bio-Sep beads) (Revision 1, 01/05/06)	Definitive	Groundwater/ DNA Extraction	Incubator	Microbial Insights	NA	N
MI SOP-DNA qPCR	Quantitative Polymerase Chain Reaction (qPCR) (Revision 1, 01/05/06)	Definitive	Groundwater/ Dehalococoides and reductase genes	Applied Biosystems	Microbial Insights	NA	N

Note: Copies of all the Laboratory SOPs listed in this table, except those noted as proprietary, can be made available to project and regulatory personnel for review upon request. If necessary proprietary SOPs may be made available for review; however, proprietary information will be obscured in these review copies.

NA – Not applicable as the DoD Quality Systems Manual (QSM) does not specify requirements for this method.

1 A Yes in this column indicates that the laboratory SOP differs slightly from the requirements of the DoD QSM. The Partnering Team accepts this variance as acceptable for this project.

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
GC/MS VOCs	Bromofluorobenzene (BFB) Tune	Prior to each Initial Calibration (ICAL) and at the beginning of each 12-hour period.	Must meet the ion abundance criteria required by the method (SW8260B; Section 7.3.1; Table 4).	Retune and/or clean or replace source. No samples may be accepted without a valid tune.	Analyst/ Supervisor	Empirical SOP-202
	Initial Calibration (ICAL) – a minimum of a 5-point calibration is prepared for all target analytes	Upon instrument receipt, for major instrument changes, or when continuing calibration verification (CCV) does not meet criteria.	The average response factor (RF) for System Performance Check Compound (SPCCs) must be ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane, ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane. The percent relative standard deviation (%RSD) for RFs for calibration check compounds (CCCs) must be $\leq 30\%$; and %RSD for each target analyte must be $\leq 15\%$, or the linear regression correlation coefficient (r) must be ≥ 0.995 ; or the coefficient of determination (r^2) must be ≥ 0.99 (6 points are required for second order).	Correct problem then repeat ICAL. No samples may be run until ICAL has passed.	Analyst/ Supervisor	
	Retention Time (RT) Window Position Establishment	Once per ICAL for each analyte and surrogate.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA.	Analyst / Supervisor	
	Evaluation of Relative Retention Times (RRTs)	With each sample.	RRT of each target analyte must be within ± 0.06 RRT units.	Correct problem, then rerun ICAL.	Analyst / Supervisor	
	Initial Calibration Verification (ICV) – Second Source	Once after each ICAL, prior to beginning a sample run.	The percent recovery (%R) for all target analytes must be within 80-120% of true values.	Correct problem and verify ICV. If that fails, correct problem and repeat ICAL. No samples may be run until ICV has been verified.	Analyst/ Supervisor	
	CCV	Perform one per 12-hour analysis period after tune and before sample analysis.	The minimum RF for SPCCs must be ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane, ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane. The percent difference or percent drift (%D) for all target analytes and surrogates must be $\leq 20\%$.	Correct problem and rerun CCV. If that fails, repeat ICAL and reanalyze all samples analyzed since the last successful CCV.	Analyst/ Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
ICP-AES Metals	ICAL - a 1-point calibration per manufacturer's guidelines is prepared for all target analytes	At the beginning of each day, or if the QC is out of criteria, prior to sample analysis.	None; only one high standard and a calibration blank must be analyzed. If more than one calibration standard is used, r must be ≥ 0.995 .	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst/ Supervisor	Empirical SOP-105
	ICV – Second Source	Following ICAL, prior to the analysis of samples.	The %R must be within 90-110% of true value.	Investigate reasons for failure, reanalyze once. If still unacceptable, correct problem and repeat ICAL.	Analyst/ Supervisor	
	CCV	At the beginning and end of the sequence and after every 10 samples.	The %R must be within 90-110% of true value.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze all affected samples.	Analyst/ Supervisor	
	Initial Calibration Blank (ICB)	Before beginning a sample sequence.	%D must be within 90%- 110%.	Correct the problem, then re-prepare and reanalyze.	Analyst / Supervisor	
	Continuing Calibration Blank (CCB)	After the initial CCV, after every 10 samples, and at the end of the sequence.	%D must be within 90%- 110%.	Correct the problem, then re-prepare and reanalyze calibration blank and all affected samples.	Analyst / Supervisor	
	Low-Level Check Standard (if using 1-point ICAL)	Daily after 1-point ICAL and before samples.	The %R must be within 80-120% of true value.	Investigate and perform necessary equipment maintenance. Recalibrate and reanalyze all affected samples.	Analyst / Supervisor	
	Interference Check Standards (ICS – ICS A and ICS B)	At the beginning of an analytical run.	The absolute value of ICS A recoveries must be $< \text{LOD}$; and ICS B recoveries must be within 80-120 %R of true value.	Terminate analysis; locate and correct problem; reanalyze ICS.	Analyst / Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
HRGC/HRMS Dioxins/ Furans	Tune / Mass Resolution Check	At the beginning and the end of each 12-hour period of analysis.	Static resolving power must be $\geq 10,000$ (10% valley) for identified masses per method and lock-mass ion between lowest and highest masses for each descriptor and level of reference must be $\leq 10\%$ full-scale deflection.	Retune instrument and verify. Assess data for impact. If end resolution is less than 10,000, narrate or re-inject, as necessary.	Analyst, Supervisor	CFA CF-OA-E-002
	GC Column Performance Check	Prior to ICAL or CCV.	Peak separation between 2,3,7,8-TCDD and other TCDD isomers must result in a valley of $\leq 25\%$ per method; <u>and</u> identification of all first and last eluters of the eight homologue retention time windows and documentation by labeling (F/L) on the chromatogram; <u>and</u> absolute retention times for switching from one homologous series to the next ≥ 10 seconds for all components of the mixture.	1) Readjust windows. 2) Evaluate system. 3) Perform maintenance. 4) Reanalyze CPSM. 5) No corrective action is necessary if 2,3,7,8-TCDD is not detected and the % valley is greater than 25%.	Analyst, Supervisor	
	ICAL – a minimum of a 5-point calibration is prepared for all target analytes	Prior to sample analysis, as needed by the failure of CCV, and when a new lot is used as a standard source.	Ion abundance ratios must be within limits specified in SOP; <u>and</u> signal to noise ratio (S/N) must be $\geq 10:1$ for all target analyte ions; and RSD must be $\leq 20\%$ for RFs for all 17 unlabelled standards and 9 labelled ISs.	Correct problem, then repeat ICAL. No samples may be run until ICAL has passed.	Analyst, Supervisor	
	CCV	At the beginning of each 12-hour period, and at the end of each analytical sequence.	Ion abundance ratios must be in accordance with SOP; <u>and</u> RF (unlabelled standards) must be $\leq 20\%D$ of average RF from ICAL; <u>and</u> RF (labelled standards) must be $\leq 30\%D$ of average RF from ICAL.	Correct problem, repeat CCV. If CCV fails, repeat ICAL and reanalyze all samples analyzed since last successful CCV <u>End of Run CCV</u> : If RF (unlabeled standards) $>20\%D$ and $\leq 25\%D$ and/or RF (labeled standards) $>30\%D$ and $\leq 35\%D$ of the average RF from ICAL, then use mean RF from bracketing CCVs to quantitate impacted samples instead of the ICAL mean RF value. If bracketing CCVs differ by more than 25% RPD (unlabeled) or 35% RPD (labeled), then run a new ICAL within 2 hours, and re-quantitate samples. Otherwise, reanalyze samples with positive detections.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
qPCR DNA Functional Genes	Initial Assay Calibration (standard curve)	Once per assay	Standard curve – Non-linear coefficient of determination (r^2) must be ≥ 0.95 .	Rerun and/or optimize assay.	Analyst, Supervisor	Microbial Insights SOP - DNA qPCR
	CCV	Primary – Semiannual Secondary – every plate (assay)	Primary: Standard curve - r^2 must be ≥ 0.95 . Replicate within 1 Threshold Cycle (CT) Secondary: CT value within 2 units of same point on standard curve.	Rerun assay / check reagents. Non conformance report—call service engineer with ABI	Analyst, Supervisor	
IC Volatile Fatty Acids	ICAL – a minimum of a 5-point calibration is prepared for all target analytes.	Perform after major instrument maintenance and upon failure of second consecutive CCV as needed.	r^2 must be ≥ 0.99 .	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst, Supervisor	Microseeps SOP AM23G
	ICV – Second Source	Once after each ICAL prior to sample analysis.	The %R of all analytes must be within 85-115% of true value.	Correct problem and verify second source standard. Reanalyze ICAL.	Analyst, Supervisor	
	CCV	At the beginning and end of the sequence and after every 10 samples.	The %R of all analytes must be within 85-115% of true value.	Repeat ICAL and reanalyze all samples analyzed since the last successful CCV.	Analyst, Supervisor	
GC-FID Dissolved Gases (MEE)	ICAL – a minimum of a 5-point calibration is prepared for all target analytes.	Perform after major instrument maintenance and upon failure of second consecutive CCV as needed.	r^2 must be ≥ 0.995 .	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst, Supervisor	Microseeps SOP AM20Gax
	ICV – Second Source	Once after each ICAL prior to sample analysis.	The %R of all analytes must be within 85-115% of true value.	Correct problem and verify second source standard. Reanalyze ICAL.	Analyst, Supervisor	
	CCV	At the beginning and end of the sequence and after every 10 samples.	The %R of all analytes must be within 85-115% of true value.	Repeat ICAL and reanalyze all samples analyzed since the last successful CCV.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
GC-FID Dissolved Gases (Hydrogen)	ICAL – a minimum of a 5-point calibration is prepared for all target analytes.	Perform after major instrument maintenance and upon failure of second consecutive CCV as needed.	The RSD for RFs for the target analyte must be $\leq 20\%$, or r^2 must be ≥ 0.995 .	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst, Supervisor	Microseeps SOP AM20Gax
	ICV – Second Source	Once after each ICAL prior to sample analysis.	The %R of the target analyte must be within 80-120% of true value.	Correct problem and verify second source standard. Reanalyze ICAL.	Analyst, Supervisor	
	CCV	At the beginning and end of the sequence and after every 10 samples.	The %R of the target analyte must be within 80-120% of true value.	Repeat ICAL and reanalyze all samples analyzed since the last successful CCV.	Analyst, Supervisor	
TOC Analyzer TOC	ICAL – a minimum of a 5-point calibration is prepared	Upon instrument receipt, major instrument change, or when the CCV does not meet criteria.	The RSD for RFs for the target analyte must be $\leq 20\%$, or r must be ≥ 0.995 .	Correct problem then repeat ICAL. No samples may be run until ICAL has passed.	Analyst, Supervisor	Empirical SOP-221
	ICV – Second Source	Once after each ICAL prior to sample analysis.	The %R must be within 90-110% of true value.	Correct problem and verify ICV. If that fails, correct problem and repeat ICAL. No samples may be run until ICV has been verified.	Analyst, Supervisor	
	CCV	Analyze standard at the beginning and end of sequence and after every 10 samples.	The %R must be within 90-110% of true value.	Correct problem and rerun CCV. If that fails, repeat ICAL and reanalyze all samples analyzed since the last successful CCV.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
IC Anions	ICAL – A minimum of a 3-point calibration is prepared and establish linear calibration range for all target analytes	Upon instrument receipt, major instrument change, or when the CCV does not meet criteria.	The RSD for RFs for each target analyte must be $\leq 20\%$, or r must be ≥ 0.995 .	Correct problem then repeat ICAL. No samples may be run until ICAL has passed.	Analyst, Supervisor	Empirical SOP-145
	ICV – Second Source	Once after each ICAL prior to sample analysis.	The %R must be within 90-110% of true value and retention times (RTs) must be within appropriate windows.	Correct problem and verify ICV. If that fails, correct problem and repeat ICAL. No samples may be run until ICV has been verified.	Analyst, Supervisor	
	CCV	Analyze standard at the beginning and end of sequence and after every 10 samples.	The %R must be within 90-110% of true value and all target analytes must be within established RT windows.	Correct problem and rerun CCV. If that fails, repeat ICAL and reanalyze all samples analyzed since the last successful CCV.	Analyst, Supervisor	
Buret Dissolved Sulfide	Standardization	Daily prior to sample analysis.	Standardized using 0.25 Normal sodium thiosulfate solution.	An acceptable titrant is compared against an independent source identified as an LCS/ICV.	Analyst, Supervisor	Empirical SOP-153
	ICV – Second Source	After ICAL and prior to sample analysis.	The %R must be within 80-120% of true value.	Recalibrate.	Analyst, Supervisor	
	CCV	At beginning and end of each run sequence and after every 10 samples.	The %R must be within 80-120% of true value.	If the CCV fails high, report samples that are less than the LOQ. Recalibrate and/or reanalyze samples back to last acceptable CCV.	Analyst, Supervisor	
Ion Probe Ammonia	Standardization	Daily prior to sample analysis.	Standardized using 1.0 and 10.0 mg/L Ammonium Chloride.	An acceptable titrant is compared against an independent source identified as an LCS/ICV.	Analyst, Supervisor	Empirical SOP-167
	ICV – Second Source	After ICAL and prior to sample analysis.	The %R must be within 90-110% of true value.	Recalibrate.	Analyst, Supervisor	
	CCV	At beginning and end of each run sequence and after every 10 samples.	The %R must be within 90-110% of true value.	If the CCV fails high, report samples that are less than the LOQ. Recalibrate and/or reanalyze samples back to last acceptable CCV.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference
Spectrophotometer Orthophosphate	ICAL – a minimum of a 5-point calibration is prepared	Upon instrument receipt, major instrument change, or when the CCV does not meet criteria.	The RSD for RFs for the target analyte must be $\leq 20\%$, or r must be ≥ 0.995 .	Correct problem then repeat ICAL. No samples may be run until ICAL has passed.	Analyst, Supervisor	Empirical SOP-165
	ICV – Second Source	Once after each ICAL prior to sample analysis.	The %R must be within 90-110% of true value.	Correct problem and verify ICV. If that fails, correct problem and repeat ICAL. No samples may be run until ICV has been verified.	Analyst, Supervisor	
	CCV	Analyze standard at the beginning and end of sequence and after every 10 samples.	The %R must be within 90-110% of true value.	Correct problem and rerun CCV. If that fails, repeat ICAL and reanalyze all samples analyzed since the last successful CCV.	Analyst, Supervisor	

Notes: *Dehalococcoides*, Functional Genes (TCE reductase, BAV1 VC reductase, VC reductase) are being collected to support the occurrence of natural attenuation and no further QC information will be presented for these analyses.

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
GC/MS	Check pressure and gas supply daily. Bake out trap and column, manual tune if BFB not in criteria, change septa as needed, cut column as needed, change trap as needed. Other maintenance specified in lab Equipment Maintenance SOP.	VOCs	Ion source, injector liner, column, column flow, purge lines, purge flow, trap.	Prior to ICAL and/or as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	Empirical SOP-202
HRGC/HRMS	Parameter Setup	Dioxins/ Furans	Physical check.	Initially; prior to daily calibration check.	Correct Parameters.	Reset if incorrect.	Analyst, Supervisor	CFA CF-OA-E-002
	Tune Check	Dioxins/ Furans	Conformance to instrument tuning.	Initially; prior to daily calibration check.	Compliance to ion abundance criteria.	Correct the problem and repeat tune check.	Analyst, Supervisor	
ICP-AES	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, replace peristaltic pump tubing as needed. Other maintenance specified in lab Equipment Maintenance SOP.	Select Metals	Torch, nebulizer chamber, pump, pump tubing.	Prior to ICAL and as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	Empirical SOP-105
GC/FID/ GC/RGD	Replace Septa, Check gases, Clean FID, replace TCD filaments, Change activated carbon, Bake out column.	Dissolved Gases	Visual inspection of septa, FID, RGD, Filaments	Prior to ICAL and as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	Microseeps SOP-AM20GAx

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
TOC Analyzer	Replace sample tubing, clean sample boat, replace syringe.	TOC	Tubing, sample boat, syringe	As needed.	Must meet ICAL and continuing calibration criteria.	Repeat maintenance activity of remove from service.	Analyst, Supervisor	Empirical SOP-221
IC	NA	Anions / Volatile Fatty Acids	NA	NA	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	Empirical SOP-145 / Microseeps SOP-AM23G
Spectrophotometer	Change lamp as needed.	Orthophosphate	Visual inspection of lamp.	Each use.	Must meet ICAL and CCV.	Try to recalibrate or contact vendor. Remove from service if not able to fix.	Analyst, Supervisor	Empirical SOP-165
Buret	NA	Dissolved Sulfide	Visual inspection for cracks or chips.	Each use.	NA.	Remove from service.	Analyst, Supervisor	Empirical SOP-153
Ion Probe	NA	Ammonia	Visual inspection of probe.	Each use.	NA.	Remove from service.	Analyst, Supervisor	Empirical SOP-167

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

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FOL or designee/ Tetra Tech
Sample Packaging (Personnel/Organization): FOL or designee/ Tetra Tech
Coordination of Shipment (Personnel/Organization): FOL or designee/ Tetra Tech
Type of Shipment/Carrier: Federal Express
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodians/ Empirical, CFA, Microseeps, and Microbial Insights
Sample Custody and Storage (Personnel/Organization): Sample Custodians/ Empirical, CFA, Microseeps, and Microbial Insights
Sample Preparation (Personnel/Organization): Extraction Laboratory, Metals Preparation Laboratory, Dioxins Preparation Laboratory, Wet Chemistry Preparation Laboratory / Empirical, CFA, Microseeps, and Microbial Insights
Sample Determinative Analysis (Personnel/Organization): GC Laboratory, GC/MS Laboratory, Metals Laboratory, Dioxins Laboratory, Wet Chemistry Laboratory / Empirical, CFA, Microseeps, and Microbial Insights
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): 60 days from receipt
Sample Extract/Digestate Storage (number of days from extraction/digestion): 3 months from sample digestion/extraction
Biological Sample Storage (Number of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: Sample Custodians/ Empirical, CFA, Microseeps, and Microbial Insights

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

27.1 SAMPLE NOMENCLATURE, SAMPLE COLLECTION DOCUMENTATION, HANDLING, TRACKING, AND CUSTODY PROCEDURES

The following sections outline the procedures that will be used to document project activities and sample collection, handling, tracking, and custody procedures during the investigation. All forms must be filled in as completely as possible.

27.1.1 Sample Identification

Refer to Worksheet #18 for how the samples will be labeled. Also, refer to Worksheet #20 for how the field QA/QC samples will be labeled.

27.1.2 Sample Collection Documentation

Documentation of field observations will be recorded in a field logbook and/or field log sheets including sample collection logs, boring logs, VOC screening logs, and monitoring well construction logs. Field logbooks utilized on this project will consist of a bound, water-resistant logbook. All pages of the logbook will be numbered sequentially and observations will be recorded with indelible ink.

Field sample log sheets will be used to document sample collection details, and other observations and activities will be recorded in the field logbook. Instrument calibration logs will be used to record the daily instrument calibration. Example field forms are included in Appendix B.

For sampling and field activities, the following types of information will be recorded in the field log as appropriate:

- Site name and location
- Date and time of logbook entries
- Personnel and their affiliations
- Weather conditions
- Activities involved with the sampling
- Subcontractor activity summary
- Site observations including site entry and exit times
- Site sketches made on site

- Visitor names, affiliations, arrival and departure times
- Health and safety issues including personal protective equipment (PPE)

27.1.3 Sample Handling and Tracking System

Following sample collection into the appropriate bottleware, all samples will be immediately placed on ice in a cooler. The glass sample containers will be enclosed in bubble-wrap in order to protect the bottleware during shipment. The cooler will be secured using strapping tape along with a signed custody seal. Sample coolers will be delivered to a local courier location for priority overnight delivery to the selected laboratory for analysis. Samples will be preserved as appropriate based on the analytical method. The laboratories will provide pre-preserved sample containers for sample collection. Samples will be maintained at ≤ 6 °C until delivery to the laboratory. Proper custody procedures will be followed throughout all phases of sample collection and handling.

After collection, each sample will be maintained in the sampler's custody until formally transferred to another party (e.g., Federal Express). For all samples collected, chain-of-custody forms will document the date and time of sample collection, the sampler's name, and the names of all others who subsequently held custody of the sample. Specifications for chemical analyses will also be documented on the chain-of-custody form. Tetra Tech SOP SA-6.3 (Field Documentation) provides further details on the chain-of-custody procedure, which is provided in Appendix B.

These subsections outline the procedures that will be used by field and laboratory personnel to document project activities and sample collection procedures during this RI. All forms must be filled in as completely as possible.

27.1.4 Sample Handling

Sample handling requirements are described in Worksheet #26. Tetra Tech personnel will collect the samples. The samplers will take care not to contaminate samples through improper handling. Samples will be sealed in appropriate containers, packaged by Tetra Tech personnel and placed into sealed coolers under chain-of-custody in accordance with the applicable SOP (See Worksheet #21). Samples to be analyzed for VOCs will be accompanied by a VOC trip blank. All coolers will contain a temperature blank. Samples will be transferred under chain-of-custody to a courier as described below. Once received by the laboratory, receipt will be documented on the chain-of-custody form and the samples will be checked in. The samples will remain under chain-of-custody throughout the analysis period to ensure their integrity is preserved. Details are provided below.

27.1.5 Sample Delivery

Samples to be delivered to the laboratory will be made by a public courier (i.e., Federal Express). After samples have been collected, they will typically be sent to the laboratory within 24 hours. Under no circumstances will sample holding times be exceeded.

27.1.6 Sample Custody

Chain-of-custody protocols will be used throughout sample handling to establish the evidentiary integrity of sample containers. These protocols will be used to demonstrate that the samples were handled and transferred in a manner that would eliminate possible tampering. Samples for the laboratory will be packaged and shipped in accordance with Tetra Tech SOP SA-6.1 (Appendix B).

A sample is under custody if:

- The sample is in the physical possession of an authorized person.
- The sample is in view of an authorized person after being in his/her possession.
- The sample is placed in a secure area by an authorized person after being in his/her possession.
- The sample is in a secure area, restricted to authorized personnel only.

Custody documentation is designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. A multi-part form is used with each page of the form signed and dated by the recipient of a sample or portion of sample. The person releasing the sample and the person receiving the sample each will retain a copy of the form each time a sample transfer occurs.

Integrity of the samples collected during the site investigation will be the responsibility of identified persons from the time the samples are collected until the samples, or their derived data, are incorporated into the final report.

The Tetra Tech FOL is responsible for the care and custody of the samples collected until they are delivered to the laboratory(s) or are entrusted to a carrier. When transferring samples, the individuals relinquishing and receiving them will sign, date, and note the time on the chain-of-custody form. This record documents the sample custody transfer from the sampler to the laboratory, often through another person or agency (common carrier). Upon arrival at the laboratory, internal sample custody procedures will be followed as defined in the laboratory SOPs.

27.1.7 Laboratory Custody

The following laboratory custody procedures are specific to Empirical, the laboratory that will analyze the VOCs and metals COCs. The laboratory custody procedures for the other laboratories will vary, but the approach to maintaining sample custody will be very similar. Custody Seals are supplied with all bottle orders. They are affixed to the cooler after sampling. The presence or absence of Custody Seals is noted on the Sample Receipt Condition Report (SRCR).

Upon receipt of samples from the field, the laboratory sample management personnel will sign off on the chain-of-custody, open the sample cooler(s), verify sample integrity and conduct a check against the chain-of-custody. If there is a discrepancy or problem (i.e. broken sample containers) the laboratory will contact the field leader or other qualified personnel and resolve the issue. Additionally, the laboratory completes a SRCR, which documents visual inspection of the samples and specific parameters such as cooler temperature, holding times, and preservation. Discrepancies or changes will be documented on the SRCR.

The laboratory sample management personnel assigns a unique laboratory work order number for the entire sample set listed on the chain-of-custody. The samples are then logged into our laboratory information management system and a Login Chain-of-Custody Report is generated. Each sample within a work order is labeled numerically. Each container of a particular sample is uniquely identified by adding an alphabetical suffix to the sample number. The laboratory labels each sample container with a Laboratory Custody Label which will remain on the sample bottle for the duration of the laboratory sample storage. The laboratory also initiates the appropriate Internal Custody Record for the sample set. Personnel fill out the Internal Custody Records to document sample removal from and return to sample storage.

A laboratory data file is also initiated for the work order. This file includes the Login Chain-of-Custody, original Chain-of-Custody, and SRCR. The folder also includes a Login File Sheet which summarizes the analyses that has been logged for the work order. This sheet is used to track data completion.

Samples for a project may be batched or grouped together by the laboratory. A series of batched work orders is referred to as a SDG. The SDG includes those samples received on a chain-of-custody, duplicate samples, and field QA/QC samples, and can include samples of different media. QA/QC samples will be run at the frequency specified in the analytical methods. The sample delivery group is given a specific identification number.

Samples are stored at the laboratory in refrigerators prior to, during, and after analysis. Refrigerators at the laboratory are constantly monitored for temperature. Proper temperatures and lighting are maintained

in the refrigerators to ensure sample integrity and preservation. Samples are retained by the laboratory for a period of 90 days after the data report is mailed to the client unless otherwise specified in a client contract. The laboratory then disposes of non-hazardous samples, following certified disposal practices. Hazardous samples are either returned to the client or disposed of through a licensed broker. Documentation of disposal is maintained by the laboratory.

Chain-of-custody requirements are also documented with instructions contained in each shipment from the laboratory as identified in Empirical SOP-QS10.

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

Matrix	Groundwater and Aqueous QC Samples					
Analytical Group	VOCs					
Analytical Method / SOP Reference	SW-846 8260B/ Empirical SOP-202					
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	One per preparatory batch of 20 or fewer samples.	All target analytes must be $\leq \frac{1}{2}$ LOQ.	Investigate source of contamination and rerun method blank prior to analysis of samples, if possible. Evaluate the samples and associated QC: if blank results are above LOQ, then report sample results which are <LOQ or >10X the blank concentration. Re-prepare and reanalyze blank and those samples that were >LOQ and <10X the blank.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
Laboratory Control Sample (LCS) / Laboratory Control Sample Duplicate (LCSD) (not required)	One is performed for each batch of up to 20 samples.	%Rs must meet the DoD Quality Systems Manual (QSM) Version 4.1 criteria, at a minimum. Also, Empirical statistically-derived %R limits. RPD must be $\leq 30\%$ (for LCS/LCSD, if an LCSD is performed).	Evaluate and reanalyze if possible. If an MS/MSD was performed in the same 12 hour clock and acceptable, then narrate. If the LCS %Rs are high, but the sample results are <LOQ, then narrate. Otherwise, re-prepare and reanalyze the LCS and associated samples.	Analyst, Supervisor, Data Validator	Accuracy/ Bias Precision also, if LCSD is analyzed	Same as QC Acceptance Limits.
MS/MSD	One per preparatory batch of 20 or fewer samples of similar matrix.	%Rs must meet the DoD QSM Version 4.1 limits as per Appendix G of the DoD QSM. The RPD between MS and MSD should be $\leq 30\%$.	Corrective action will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met unless RPDs indicate obvious extraction/ analysis difficulties, then re-prepare and reanalyze MS/MSD.	Analyst, Supervisor, Data Validator	Accuracy/ Bias/ Precision	Same as QC Acceptance Limits

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Internal Standards (IS)	Every field sample, standard, and QC sample - three per sample- Fluorobenzene Chlorobenzene-d5 1,4-dichlorobezene-d4	RTs must be within ± 30 seconds and the response areas must be within -50% to +100% of the ICAL midpoint standard for each IS.	Inspect mass spectrometer and gas chromatograph for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Analyst, Supervisor, Data Validator	Accuracy	Same as QC Acceptance Limits.
Surrogates	All field and QC samples - four per sample- Dibromofluoromethane 1,2-dichloroethane-d4 Toluene-d8 BFB	%Rs must meet the DoD QSM Version 4.1 limits as per Appendix G of the DoD QSM.	If sample volume is available, then re-prepare and reanalyze sample for confirmation of matrix interference when appropriate.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits.
Results between DL and LOQ	NA	Apply "J" qualifier to results detected between DL and LOQ.	NA.	Analyst, Supervisor, Data Validator	Accuracy	Same as QC Acceptance Limits.

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	One per preparatory batch of 20 or fewer samples of similar matrix.	All target analytes must be $\leq \frac{1}{2}$ LOQ.	If the blank value > LOQ, then report sample results. If the blank value < LOQ or > 10x the blank value, then redigest. If blank value is less than negative LOQ, then report sample results. If > 10x the absolute value of the blank result, then redigest and reanalyze.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples of similar matrix.	%R must be within 80-120% of true value.	Evaluate and reanalyze, if possible. If the LCS recoveries are high, but the sample results are < LOQ, then narrate. Otherwise, re-digest and reanalyze all associated samples for failed target analyte(s).	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits.
MS	One per preparatory batch of 20 or fewer samples of similar matrix.	%R should be within 80-120% of true value (if sample is < 4x spike added).	Flag results for affected analytes for all associated samples with "N".	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits.
Sample Duplicate	One per preparatory batch of 20 or fewer samples of similar matrix.	The RPD should be $\leq 20\%$ for duplicate samples.	Narrate any results that are outside control limits.	Analyst, Supervisor, Data Validator	Precision	Same as QC Acceptance Limits.
Serial Dilution	One per preparatory batch with sample concentration(s) >50x LOD.	The 5-fold dilution result must agree within $\pm 10\%D$ of the original sample result if result is >50x LOD.	Perform post spike addition.	Analyst, Supervisor, Data Validator	Precision	Same as QC Acceptance Limits.

Matrix	Groundwater and Aqueous QC Samples					
Analytical Group	Metals					
Analytical Method / SOP Reference	SW-846 6010C/ Empirical SOP-105					
QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Post Spike	One is performed when serial dilution fails or target analyte concentration(s) in all samples are < 50x LOD.	The %R must be within 75-125% of expected value to verify the absence of an interference. Spike addition should produce a concentration of 10-100x LOQ.	Flag results for affected analytes for all associated samples with "J".	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits.
Results between DL and LOQ	NA.	Apply "J" qualifier to results between DL and LOQ.	NA.	Analyst, Supervisor, Data Validator	Accuracy	Same as QC Acceptance Limits.

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	One per preparatory batch of 20 or fewer samples.	All target analytes must be \leq LOQ.	Correct problem. If required, re-prepare and reanalyze method blank and all samples processed with the contaminated blank. "Totals" are not considered "target analytes" – no corrective action or flagging is necessary for "totals".	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
IS	Every field sample, standard and QC sample.	The %R for each IS must be within 25-150%, per method.	Correct problem, then re-prepare and reanalyze the samples with failed IS.	Analyst, Supervisor, Data Validator	Accuracy	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples of similar matrix.	%Rs must meet the DoD QSM Version 4.1 limits as per Appendix G of the DoD QSM.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed target analytes, if sufficient sample material is available.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples of similar matrix.	%Rs must meet the DoD QSM Version 4.1 limits as per Appendix G of the DoD QSM. The RPD between MS and MSD should be \leq 30%.	Identify problem; if not related to matrix interference, re-extract and reanalyze MS/MSD and all associated batch samples in accordance with DoD QSM requirements.	Analyst, Supervisor, Data Validator	Accuracy/ Bias/ Precision	Same as QC Acceptance Limits

Matrix	Groundwater					
Analytical Group	Dissolved Gases (MEE and Hydrogen)					
Analytical Method / SOP Reference	RSK SOP 175/ Microseeps SOP-AM20Gx					
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	One per batch of up to 20 samples.	All target analytes must be \leq LOQ.	Correct problem, re-prepare and reanalyze along with all associated samples.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
Calibration Blank	At the beginning of analytical sequence, after every 10 samples, and at the end of the sequence.	All target analyte concentrations must be $<$ LOD.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples.	%R must be within 80-120% of the true value.	Correct problem, reprepare, and reanalyze the LCS along with all associated samples.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits.
MS/MSD	One per batch of up to 20 samples.	%R should be within 70-130% of the true value. RPD between MS and MSD should be \leq 20%.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Accuracy/ Bias Precision	Same as QC Acceptance Limits.

Matrix	Groundwater					
Analytical Group	Volatile Fatty Acids					
Analytical Method / SOP Reference	SW-846 9056 A/ Microseeps SOP-AM23G					
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	One per batch of up to 20 samples.	All target analytes must be \leq LOQ.	Correct problem, re-prepare and reanalyze along with all associated samples.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per batch of up to 20 samples.	%R must be within 70-130% of the true value.	Correct problem, reprepare, and reanalyze the LCS along with all associated samples.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits.
MS/MSD	One per batch of up to 20 samples.	%R should be within 70-130% of the true value. RPD between MS and MSD should be \leq 30%.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Accuracy/ Bias Precision	Same as QC Acceptance Limits.

Matrix	Groundwater					
Analytical Group	TOC					
Analytical Method / SOP Reference	SW-846 9060A/ Empirical SOP-221					
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	One per preparatory batch of 20 or fewer samples.	The target analyte must be $\leq \frac{1}{2}$ LOQ.	Correct problem, re-prepare and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 80-120% of true value.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix.	%R should be within 80-120% of true value. RPD should be $\leq 20\%$.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Accuracy/ Bias/ Precision	Same as QC Acceptance Limits

Matrix	Groundwater					
Analytical Group	Anions					
Analytical Method / SOP Reference	SW-846 9056A Empirical SOP-145					
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	One per preparatory batch of 20 or fewer samples.	All target analytes must be $\leq \frac{1}{2}$ LOQ.	Correct problem, reprepare and reanalyze along with all associated samples.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples of similar matrix.	%R must be within 80-120% of true value.	Correct problem, reprepare, and reanalyze the LCS along with all associated samples.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples of similar matrix.	%R should be within 80-120% of true value. RPD should be $\leq 15\%$.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Accuracy/ Bias/ Precision	Same as QC Acceptance Limits
Sample Duplicate (Replicate)	One per every 10 samples.	RPD must be $\leq 10\%$.	Correct problem and reanalyze sample and duplicate.	Analyst, Supervisor, Data Validator	Precision	Same as QC Acceptance Limits.

Matrix	Groundwater					
Analytical Group	Dissolved Sulfide					
Analytical Method / SOP Reference	SM4500S F Empirical SOP-153					
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	One per preparatory batch of 20 or fewer samples.	No target analyte \geq LOD.	Correct problem. If required, re-prepare and reanalyze method blank and all samples processed with the contaminated blank.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples of similar matrix.	Must be within method specified %R of 80-120% of true value.	Correct problem, then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analyte, if sufficient sample material is available.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits
Duplicate Sample	One per preparatory batch of 20 or fewer samples of similar matrix.	RPD should be \leq 20%.	Identify problem; if not related to matrix interference, re-extract and reanalyze duplicates and all associated batch samples in accordance with DoD QSM requirements.	Analyst, Supervisor, Data Validator	Precision	Same as QC Acceptance Limits

Matrix	Groundwater					
Analytical Group	Orthophosphate					
Analytical Method / SOP Reference	SM 4500PM Empirical SOP-165					
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	One per preparatory batch of 20 or fewer samples.	Analyte concentration must be \leq $\frac{1}{2}$ LOQ.	Correct problem, reprepare and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 80-120% of true value.	Correct problem, reprepare, and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples of similar matrix.	%R should be within 75-125% of true value. RPD should be \leq 20%.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Accuracy/ Bias/ Precision	Same as QC Acceptance Limits
Duplicate Sample	One per preparatory batch of 20 or fewer samples per matrix.	RPD should be \leq 20%.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Precision	Same as QC Acceptance Limits

Matrix	Groundwater					
Analytical Group	Ammonia					
Analytical Method / SOP Reference	SM 4500NH3D Empirical SOP-167					
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	One per preparatory batch of 20 or fewer samples.	Analyte concentration must be \leq $\frac{1}{2}$ LOQ.	Correct problem, reprepare and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Bias/ Contamination	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 80-120% of true value.	Correct problem, reprepare, and reanalyze along with associated samples.	Analyst, Supervisor, Data Validator	Accuracy/ Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples of similar matrix.	%R should be within 75-125% of true value. RPD should be \leq 20%.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Accuracy/ Bias/ Precision	Same as QC Acceptance Limits
Duplicate Sample	One per preparatory batch of 20 or fewer samples per matrix.	RPD should be \leq 20%.	Contact client for guidance.	Analyst, Supervisor, Data Validator	Precision	Same as QC Acceptance Limits

SAP Worksheet #29 -- Project Documents and Records Table
 (UFP-QAPP Manual Section 3.5.1)

DOCUMENT	LOCATION MAINTAINED
<p>Sample Collection Documents and Records:</p> <ul style="list-style-type: none"> • Field logbook (and sampling notes) • Field sample forms (e.g. boring logs, sample log sheets, drilling logs, etc.) • Chain-of-custody records • Sample shipment airbills • Equipment calibration logs • Photographs • Field Task Modification Forms • SAP • Field Sampling SOPs 	<p>Sample collection documents will be maintained in the project file located in the Tetra Tech Jacksonville, Florida office.</p>
<p>Laboratory Documents and Records:</p> <ul style="list-style-type: none"> • Sample receipt/login form • Equipment calibration logs • Sample analysis run logs • Corrective Action (CA) forms • Reported results for standards, QC checks, and QC samples • Data completeness checklists • Raw data 	<p>Laboratory documents will be included in the hardcopy and Portable Document Format (PDF) deliverables from the laboratory. Laboratory data deliverables will be maintained in the Tetra Tech Jacksonville, Florida project file and in long-term data package storage at a third-party professional document storage firm.</p> <p>Electronic data results will be maintained in a database on a password protected Structured Query Language (SQL) server.</p>
<p>Other Documents</p> <ul style="list-style-type: none"> • HASP • All versions of SAP • All letter and e-mail correspondence with regulatory agencies, including approvals and comments • Signed Worksheets #1 and #4 • Field Investigation data packages • Data Validation Memoranda (includes tabulated data summary forms) • All version of project reports 	<p>All versions of the project report and all support documents (e.g., Data Validation Reports) will be stored in hardcopy in the Tetra Tech Jacksonville, Florida project file and electronically in the server library.</p>

Data Handling and Management - After the investigation is completed, the 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 the 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 subcontract laboratories will meet the requirements of the technical specifications. The electronic data results will be automatically downloaded into the Tetra Tech database in accordance with the proprietary Tetra Tech processes.

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 Tetra Tech Project Chemist (or designee) is responsible for tracking the samples collected and shipped to each subcontract laboratory. Upon receipt of the data packages from each subcontract laboratory, the Tetra Tech Project Chemist will oversee the data validation effort, which includes verifying that the data packages are complete and that results for all samples have been delivered by each subcontract laboratory.
- **Data Storage, Archiving, and Retrieval.** The data packages received from each subcontract laboratory are tracked in the data validation logbook. After the data are validated, the data packages are entered into the Tetra Tech Navy CLEAN file system and archived in secure files. The field records including field logbooks, sample log sheets, chain-of-custody records, and field calibration logs will be submitted by the Tetra Tech FOL to be entered into the Navy 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. Access to Tetra Tech project files is restricted to designated personnel only. Records can only be borrowed temporarily from the project file using a sign-out system. The Tetra Tech Data Manager maintains the electronic data files, and access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

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

MATRIX	ANALYTICAL GROUP	SAMPLE LOCATIONS/ IDENTIFICATION NUMBERS	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)
Groundwater	VOCs	See Worksheet #18	SW-846 8260B	21 calendar days	Brian Richard brichard@empirlabs.com Empirical Laboratories, LLC 621 Mainstream Drive, Suite 270 Nashville, TN 37228 (615) 345-1115	NA
	Metals		SW-846 6010C			
	TOC		SW-846 9060A			
	Anions (chloride and sulfate)		SW-846 9056A			
	Dissolved Sulfide		SM 4500S F			
	Orthophosphate		SM4500PM			
	Ammonia		SM4500NH3D			
Groundwater	Dioxins/Furans	See Worksheet #18	SW-846 8290A	21 calendar days	Chris Cornwell ccornwell@cfanalytical.com Cape Fear Analytical, LLC 3306 Kitty Hawk Road Suite 120 Wilmington, NC 28405 (910) 795-0422	NA
Groundwater	Dissolved Gases (MEE and Hydrogen)	See Worksheet #18	RSK SOP 175	21 calendar days	Robbin Robl rrobl@microseeps.com Microseeps, Inc. 220 William Pitt Way Pittsburgh, PA 15238 (412) 826-5245	NA
	Volatile Fatty Acids		Laboratory proprietary SOP			

MATRIX	ANALYTICAL GROUP	SAMPLE LOCATIONS/ IDENTIFICATION NUMBERS	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)
Groundwater	Dehalococcoides and reductase genes	See Worksheet #18	Laboratory proprietary SOP	21 calendar days	Anita Biernacki abiernacki@microbe.com Microbial Insights, Inc. 2340 Stock Creek Boulevard Rockford, TN 37853-3044 (865) 573-8188 x108	NA

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 CA (title and organizational affiliation)	PERSON(S) RESPONSIBLE FOR MONITORING EFFECTIVENESS OF CA (title and organizational affiliation)
Laboratory System Audit ¹	Every two years	External	DoD ELAP Accrediting Body	DoD ELAP Accrediting Body Auditor	Laboratory QAM or Laboratory Manager, Empirical and CFA	Laboratory QAM or Laboratory Manager, Empirical and CFA	Laboratory QAM or Laboratory Manager, Empirical and CFA

¹ Empirical and CFA are DoD ELAP accredited for all analytical groups and target analytes required for this project. Microseeps and Microbial Insights are specialty support laboratories and do not require DoD ELAP accreditation. The DoD ELAP accreditation documentation is included in Appendix D.

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)	TIMEFRAME OF NOTIFICATION	NATURE OF CORRECTIVE ACTION RESPONSE DOCUMENTATION	INDIVIDUAL(S) RECEIVING CORRECTIVE ACTION RESPONSE (name, title, organization)	TIMEFRAME FOR RESPONSE
Laboratory System Audit	Written audit report	Marcia McGinnity, Laboratory QAM, Empirical Laboratories, LLC Chris Cornwell, Laboratory Director/Laboratory PM, CFA	Specified by DoD ELAP Accrediting Body	Letter	DoD ELAP Accrediting Body	Specified by DoD ELAP Accrediting Body

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 SDG	Within 3 weeks of receipt of laboratory data	DVM or designee, Tetra Tech	PM and project file, Tetra Tech
Project monthly progress report	Monthly for duration of the project	Monthly	Tetra Tech PM, Tetra Tech	PM, CLEAN QAM, Program Manager, and project file, Tetra Tech
Laboratory QA Report	When significant plan deviations result from unanticipated circumstances	Immediately upon detection of problem	Laboratory PM,	PM and project file, Tetra Tech

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 form to verify that all samples listed are included in the shipment to the laboratory and the sample information is accurate. The forms will be signed by the sampler and a copy will be retained for the project file, the Tetra Tech PM, and the Tetra Tech Data Validators.	Internal	Sampler and FOL, Tetra Tech
	The Laboratory Sample Custodian will review the sample shipment for completeness, integrity, and sign accepting the shipment. The Tetra Tech Data Validators 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.	Internal/ External	1 - Laboratory Sample Custodian, Empirical, CFA, Microseeps, and Microbial Insights 2 - Data Validators, Tetra Tech
SAP Sample Tables/ Chain-of-Custody Forms	Verify that all proposed samples listed in the SAP tables have been collected.	Internal	FOL or designee, Tetra Tech
Sample Log Sheets	Verify that information recorded in the log sheets is accurate and complete.	Internal	FOL or designee, Tetra Tech
SAP/ Field Logs/ Analytical Data Packages	Ensure that all sampling SOPs were followed. Verify that deviations have been documented and MPCs 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 trail of documented 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.	Internal	PM or designee, Tetra Tech
SAP/ Laboratory SOPs/ Raw Data/ Applicable Control Limits Tables	Ensure that all laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied. Establish that all method QC samples were analyzed and in control as listed in the analytical SOPs. If method QA is not in control, the Laboratory QAM will contact the Tetra Tech PM via telephone or e-mail for guidance prior to report preparation.	Internal	Laboratory QAM, Empirical, CFA, Microseeps, and Microbial Insights

Verification Input	Description	Internal / External	Responsible for Verification (name, organization)
SAP/ Chain-of-Custody Forms	Check that field QC samples listed in Worksheet #20 were collected as required.	Internal	FOL or designee, Tetra Tech
Analytical Data Packages	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, Empirical, CFA, Microseeps, and Microbial Insights
Electronic Data Deliverables (EDDs)/ Analytical Data Packages	Each EDD 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 DL and the LOQ will be qualified as estimated. Extraneous laboratory qualifiers will be removed from the validation qualifier.	External	Data Validators, Tetra Tech
	Each data package will be verified for completeness by the Tetra Tech Data Validator. Missing information will be requested by the Tetra Tech Data Validator from the Laboratory PM.	External	Data Validators, Tetra Tech
SAP/ Laboratory SOPs/ Raw Data/ Applicable Control Limits Tables	Ensure that all laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied. Establish that all method QC samples were analyzed and in control as listed in the analytical SOPs. If method QA is not in control, the Laboratory QAM will contact the Tetra Tech PM via telephone or e-mail for guidance prior to report preparation.	Internal	Laboratory QAM, Empirical, CFA, Mcroseeps, and Microbial Insights

SAP Worksheet #35 -- Validation (Steps IIa and IIb) Process Table
 (UFP-QAPP Manual Section 5.2.2) (Figure 37, page 110 UFP-QAPP Manual) (Table 9 UFP-QAPP Manual)

Step IIa / IIb	Validation Input	Description	Responsible for Validation (name, organization)
IIa	SAP/ Sample Log Sheets	Ensure that sample locations are correct and in accordance with the SAP proposed locations. Document any discrepancies in the final report.	PM, FOL, or designee, Tetra Tech
IIa	Chain-of-Custody Forms	Ensure that the custody and integrity of the samples was maintained from collection to analysis and the custody records are complete and any deviations are recorded. Review that the samples were shipped and stored at the required temperature and sample pH for chemically-preserved samples meet the requirements listed in Worksheet #19. Ensure that the analyses were performed within the holding times listed in Worksheet #19.	Project Chemist or Data Validators, Tetra Tech
IIa/IIb	SAP/ Laboratory Data Packages/ EDDs	Ensure that the laboratory QC samples listed in Worksheet #28 were analyzed and that the MPCs 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.	Project Chemist or Data Validators, Tetra Tech
		Check the field sampling precision by calculating the RPD for field duplicate samples. Check the laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses; MS/MSDs; and LCS/LCSD, if available. Ensure compliance with the methods and project MPCs accuracy goals listed in Worksheet #12.	
		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.	
		Review the chain-of-custody forms 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. The Tetra Tech Data 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 SQL database.	

Step IIa / IIb	Validation Input	Description	Responsible for Validation (name, organization)
IIb	SAP/ Laboratory Data Packages/ EDDs	Ensure that the project LOQs listed in Worksheet #15 were achieved.	Project Chemist or Data Validators, Tetra Tech
		Discuss the impact on reported DLs due to matrix interferences or sample dilutions performed because of the high concentration of one or more other contaminants, on the other target compounds reported as non-detected. Document this usability issue and inform the Tetra Tech PM. Review and add PSLs to the laboratory EDDs. Flag samples and notify the Tetra Tech PM of samples that exceed PSLs listed in Worksheet #15.	
		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 QAM shall have contacted the Tetra Tech PM.	
		Summarize deviations from methods, procedures, or contracts in the Data Validation Report. Determine the impact of any deviation from sampling or analytical methods and SOPs requirements and matrix interferences effect on the analytical results. Qualify data results based on method or QC deviation and explain all the data qualifications. Print a copy of the project database qualified data depicting data qualifiers and data qualifiers codes that summarize the reason for data qualifications. Determine if the data met the MPCs and determine the impact of any deviations on the technical usability of the data.	

SAP Worksheet #36 –Analytical Data Validation (Steps IIa and IIb) Summary Table
 (UFP-QAPP Manual Section 5.2.2.1) (Figure 37, page 110 UFP-QAPP Manual)

STEP IIa / IIb	MATRIX	ANALYTICAL GROUP	VALIDATION CRITERIA	DATA VALIDATOR (title and organizational affiliation)
IIa and IIb	Groundwater	VOCs	Data validation will be performed using criteria for SW-846 Method 8260B listed in Worksheets #12, #15, #24, and #28 and the current DoD QSM. If not included in the aforementioned, then the logic outlined in the “USEPA CLP National Functional Guidelines for Organic Data Review” USEPA-540/R-99-008, (USEPA, October 1999) will be used to apply qualifiers to data.	Data Validation Specialist, Tetra Tech
IIa and IIb	Groundwater	Metals	Data validation will be performed using criteria for SW-846 Method 6010C listed in Worksheets #12, #15, #24, and #28 and the current DoD QSM. If not included in and the aforementioned, then the logic outlined in the “USEPA CLP National Functional Guidelines for Inorganic Data Review”, USEPA 540-R-04-004, (USEPA, October 2004) will be used to apply qualifiers to data.	Data Validation Specialist, Tetra Tech

STEP IIa / IIb	MATRIX	ANALYTICAL GROUP	VALIDATION CRITERIA	DATA VALIDATOR (title and organizational affiliation)
IIa and IIb	Groundwater	Dioxins and Furans	Data validation will be performed using criteria for SW-846 Method 8290A listed in Worksheets #12, #15, #24, and #28 and the current DoD QSM. If not included in the aforementioned, then the logic outlined in the "National Functional Guidelines for Chlorinated Dioxin/Furan Data Validation", (USEPA, September 2005) will be used to apply qualifiers to data.	Data Validation Specialist, Tetra Tech
IIa and IIb	Groundwater	Dissolved Gases, Volatile Fatty Acids, TOC, Anions, Dissolved Sulfide, Orthophosphate, and Ammonia	Limited data validation* will be performed using criteria for Methods RSK SOP 175, SW-846 9056A, 9060A, SM 4500S F, SM 4500PM, SM 4500NH3D, and SM 2320B listed in Worksheets #12, #15, #24, and #28.	Data Validation Specialist, Tetra Tech

Notes:

* Limited data validation. Limits the data review to specific review parameters (Data Completeness/Data Verification, Holding Times, Calibrations, Blank Contamination, & Detection Limits) to determine gross deficiencies only. The limited data validation is best expressed as a review to preclude the possibility of false negatives and to eliminate false positives. Raw data are not evaluated and sample result verification is not conducted. A formal report, similar to a full data validation report, is prepared but the scope is more limited than a full validation report. The data packages provided by the laboratory will be expansive enough to allow future complete formal data validation, if necessary.

Dehalococoides and reductase genes data reports will not be validated.

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 DQI characteristics:

Completeness

For each matrix that was scheduled to be sampled, the Tetra Tech FOL acting on behalf of the Partnering 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 and risk assessor 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 Partnering Team members, as necessary (determined by the Navy RPM), to develop appropriate corrective actions.

Precision

The Tetra Tech Project Chemist acting on behalf of the Partnering 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 laboratory duplicate results will be no less precise than field 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 Tetra Tech Project Chemist acting on behalf of the Partnering Team will determine whether the accuracy/bias goals were met for project data. This will be accomplished by comparing percent recoveries of LCS, LCSD, MS, MSD, and surrogate compounds to accuracy goals identified in Worksheet #28. This assessment will include an evaluation of field and laboratory

DATA USABILITY ASSESSMENT

contamination; instrument calibration variability; and analyte recoveries for surrogates, MS, and LCSs. 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 Partnering Team will determine whether the data are adequately representative 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, by 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 Tetra Tech Project Chemist acting on behalf of the Partnering 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 Tetra Tech Project Chemist indicates that such quantitative analysis is required.

Sensitivity

The Tetra Tech Project Chemist acting on behalf of the Partnering 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 Tetra Tech 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 PM 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.

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 statistical analyses will be performed to estimate these characteristics. The statistical 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 Partnering 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 statistical comparisons and 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.

DATA USABILITY ASSESSMENT

Identify the personnel responsible for performing the usability assessment:

The Tetra Tech PM, 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, Tetra Tech PM, and the MDEQ RPM. 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-compliance 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.

REFERENCES

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HLA (Harding Lawson Associates), 1988. Final Verification Report, Naval Construction Battalion Center, Gulfport, Mississippi. July.

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MDEQ (Mississippi Department of Environmental Quality), 2002. Tier 1 TRG Table for soil and groundwater (unrestricted and restricted use), Appendix A of the Final Governing Brownfields Voluntary Cleanup and Redevelopment in Mississippi. February.

Tetra Tech, 2009a. Remedial Investigation Report for Site 4 – Golf Course Landfill, NCBC, Gulfport, Mississippi. Prepared for NAVFAC SE, Jacksonville, Florida. November.

Tetra Tech, 2009b. Feasibility Study for Site 4 – Golf Course Landfill, NCBC, Gulfport, Mississippi. Prepared for NAVFAC SE, Jacksonville, Florida. November.

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USEPA, 1996. *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills*. United States USEPA Office of Solid Waste and Emergency Response. Washington, D.C. OSWER Directive 9355.067-FS USEPA/540/F-96/020. December.

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USEPA, 2005. Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP), Evaluating, Assessing, and Documental Environmental Data Collection and Use Programs. Part 1: UFP-QAPP Manual. Final Version 1. USEPA: USEPA-505-B-04-900A; DoD: DTIC ADA 427785.

REFERENCES (CONTINUED)

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USEPA, 2010, Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites, Residential Direct Contact (R-RSL).

APPENDIX A

DATA QUALITY OBJECTIVES PRESENTATION

DQO Presentation Gulfport NCBC

Site 4 – Golf Course Landfill Groundwater Plume Evaluation Gulfport, Mississippi

Sites 4 - Site Boundary





Site 4 - Background

- Operated from 1966 to 1972
- 16,000 tons of solid waste including debris from damage due to Hurricane Camille
- 20,000 gallons of waste liquids including fuels, oils, solvents, paints, paint thinners.
- Used as part of the Pine Bayou Golf Course
- Future use planned to be as part of the “Golf Experience”



Site 4 – Assessment History

- Various investigations from 1984 to 1994
- 1984 - Initial Assessment Study (Envirodyne)
- 1987 - Verification Report (Harding Lawson)
- 1998 - Interim Removal Action Report
- 1999 - Groundwater Monitoring Report
- 2004-2007 - Remedial Investigation. Data from this investigation was collected to support Feasibility Study.
- 2009 - Feasibility Study
- 2010 - Record of Decision

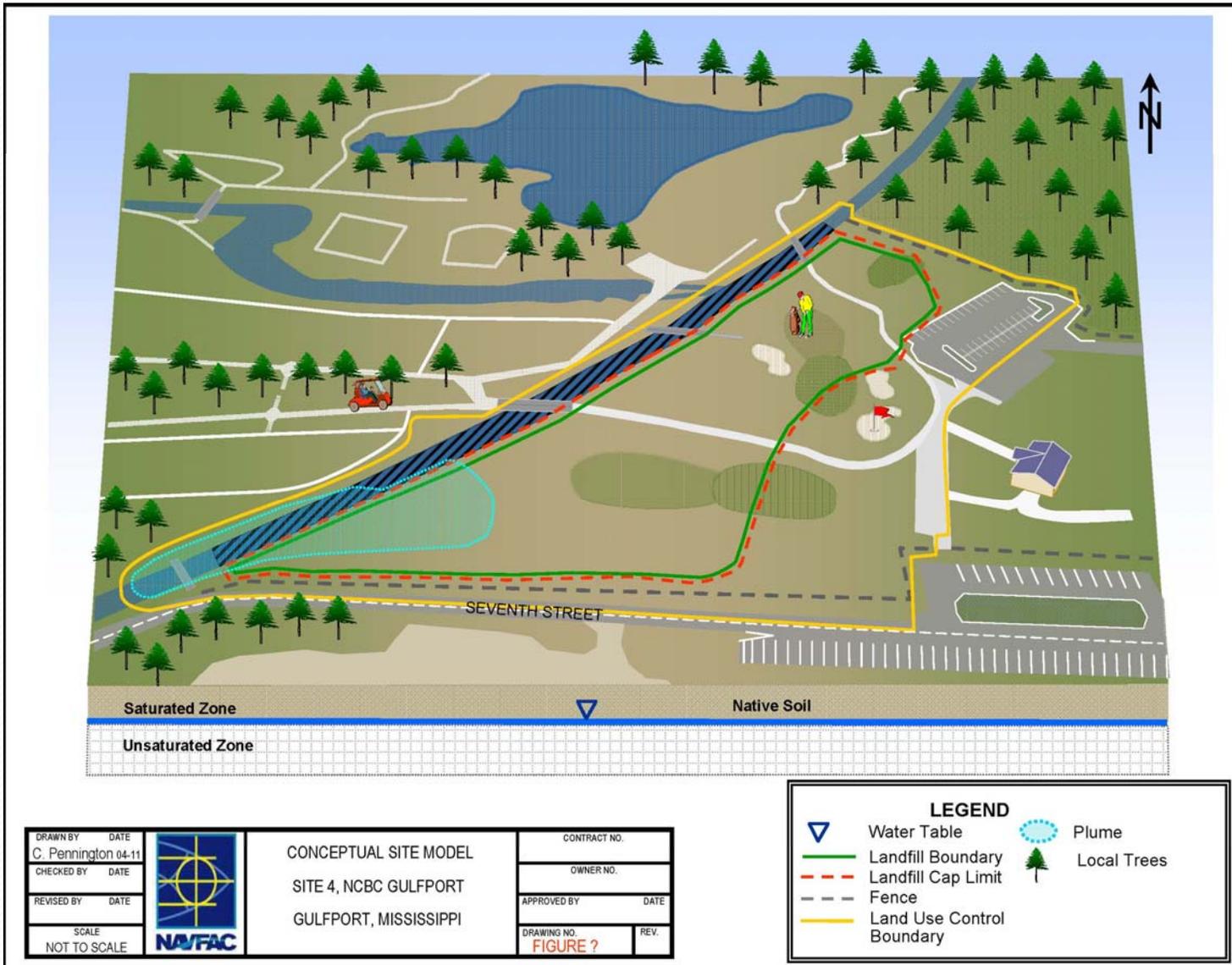


Site 4 – Record of Decision

Presumptive Remedy:

- Engineered landfill cap
- Landfill gas management system
- Sediment removal and lining of Canal No. 1
- Land Use Controls
- Groundwater monitoring

Site 4 – Conceptual Site Model



Sites 4 – Proposed Sample Locations





Site 4 – Problem Statement

Golf Course Landfill

- Evaluate the current conditions of the existing groundwater plume.
- Collect hydrogeologic data to determine if groundwater enhancement is necessary.
- Based on the results of the investigation, the Navy will determine if additional treatment is appropriate to accelerate the degradation of the groundwater contamination.

Site 4 – Information Inputs

- Previously collected data for trend analysis
- Chemical Data: TCE, cDCE, tDCE, VC, Iron, Manganese, and Dioxins
- MNA Parameters: ammonia , sulfate, sulfide , chloride, orthophosphate , methane, ethane, ethene, light gases, volatile fatty acids, and TOC
- Reducing bacteria and enzymes
- Groundwater field parameters: dissolved oxygen, temperature, oxidation reduction potential, pH, and turbidity
- Project Action Levels (PALs): USEPA Maximum Contaminant Level and MDEQ Tier 1 Target Remedial Goals



Site 4 – Evaluation Process

- Groundwater sampling
- Install monitoring wells surrounding the previously defined groundwater plume boundaries (including down gradient and side gradient wells)
 - Note: During the March 2011 partnering meeting re-installation of wells into the previous source (i.e., highest concentrations) areas through the cap was discussed. This will not be performed unless agreed to later as a necessity.



Site 4 – Groundwater Plume Evaluation Decision Rule

If COC concentrations surrounding the perimeter of the known chlorinated groundwater plume are less than project action levels, then proceed to long term monitoring in accordance with the Decision Document. If COC concentrations surrounding the perimeter of the known plume exceed project action levels, then continue to define the extent of contaminant migration as necessary. Once complete with the evaluation, the Navy will determine if additional treatment is warranted to accelerate remediation times.

APPENDIX B

FIELD STANDARD OPERATING PROCEDURES AND FIELD FORMS

Tetra Tech NUS, Inc.

PROJECT: _____ LOCATION: _____
 JOB & CTO #: _____ MOBILIZATION DATE: _____
 PROJECT MANAGER: _____ RETURN DATE: _____

FIELD PROJECT PRE-MOBILIZATION CHECKLIST	
TRAVEL	MISCELLANEOUS
<input type="checkbox"/> Airline reservations <input type="checkbox"/> Hotel reservations/BOQs <input type="checkbox"/> Vehicle rental <input type="checkbox"/> Itinerary <input type="checkbox"/> Phone/pager number	Schedule <input type="checkbox"/> Plan field operations w/ Project manager Documents for Field Program <input type="checkbox"/> Logbook(s) <input type="checkbox"/> Field Sampling plan <input type="checkbox"/> Health & Safety plan <input type="checkbox"/> Maps <input type="checkbox"/> H & S Guidance Manual Authorization <input type="checkbox"/> Kick-off meeting held <input type="checkbox"/> Gov't rate letter <input type="checkbox"/> H&S/OSHA 40-hour certificate <input type="checkbox"/> 8-Hour Refresher Training Certificate <input type="checkbox"/> Medical Clearance Letter <input type="checkbox"/> Supervisory Training Certificate <input type="checkbox"/> Health & Safety Clearance Letter <input type="checkbox"/> Full-size OSHA Poster
DRILLING/DPT/SURVEY	HYDROGEOLOGY EQUIPMENT
Subcontractor <input type="checkbox"/> POC phone #/address <input type="checkbox"/> Drill Specification RFP <input type="checkbox"/> Contact (time & place to meet) <input type="checkbox"/> Confirm subcontract w/ TtNUS Procurement <input type="checkbox"/> Health and Safety documentation for all personnel on site <input type="checkbox"/> Copy of Drillers license <input type="checkbox"/> Well / boring permits Utilities (2 weeks lead time) <input type="checkbox"/> Contact Site POC (Date: _____) <input type="checkbox"/> Contact Local "Call Before You Dig" <input type="checkbox"/> Utility Clearance Form Forms <input type="checkbox"/> Boring logs / Test Pit logs <input type="checkbox"/> Well construction / development forms <input type="checkbox"/> Daily activity forms <input type="checkbox"/> IDW inventory <input type="checkbox"/> IDW drum labels <input type="checkbox"/> Chemical Inventory <input type="checkbox"/> MSDS's	<input type="checkbox"/> Slug test/pumping test forms <input type="checkbox"/> Groundwater elevation data sheets <input type="checkbox"/> Graph paper <input type="checkbox"/> Data Logger/transducer/data cable <input type="checkbox"/> Existing well construction & water level data <input type="checkbox"/> M-Scope, slug
EQUIPMENT MOBILIZATION	SHIPPING
<input type="checkbox"/> Equipment Requisition form completed / equipment ordered <input type="checkbox"/> 3rd Party rental / misc. equipment ordered <input type="checkbox"/> Equipment calibration forms <input type="checkbox"/> Span / calibration gas and regulator	Forms <input type="checkbox"/> FedEx Airbills, local dropoff location & hours <input type="checkbox"/> FedEx Gov. Acct# (1771-8058-0) <input type="checkbox"/> Lab Shipping Labels <input type="checkbox"/> Warehouse Shipping Labels <input type="checkbox"/> Blank Labels Supplies <input type="checkbox"/> Tape <input type="checkbox"/> Packing materials <input type="checkbox"/> Baggies, Large garbage bags
SAMPLING	OTHER
Forms <input type="checkbox"/> Sample log sheets <input type="checkbox"/> Low-flow purge data sheets <input type="checkbox"/> COC records <input type="checkbox"/> COC seals <input type="checkbox"/> Sample labels (from database group) Laboratory <input type="checkbox"/> POC address/phone# <input type="checkbox"/> Order bottles / preservatives <input type="checkbox"/> Shipping address, also check Sat. address <input type="checkbox"/> Bottle & preservation req'ts from lab	<input type="checkbox"/> Site POC name/phone # <input type="checkbox"/> Personnel information to POC <input type="checkbox"/> Mobilization schedule to POC <input type="checkbox"/> Site access authorizations <input type="checkbox"/> Field office / trailer arrangements made <input type="checkbox"/> Electric, phone hookups arranged <input type="checkbox"/> Steel-toed boots, safety glasses, & hard hat <input type="checkbox"/> First aid equipment <input type="checkbox"/> Insect repellent <input type="checkbox"/> _____ <input type="checkbox"/> _____

Note - not all items listed apply to every job, and some additional requirements may apply on a job-specific basis.

Tetra Tech NUS, Inc.

PROJECT: _____

JOB #: _____

LOCATION: _____

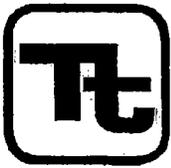
DATE: _____

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
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.

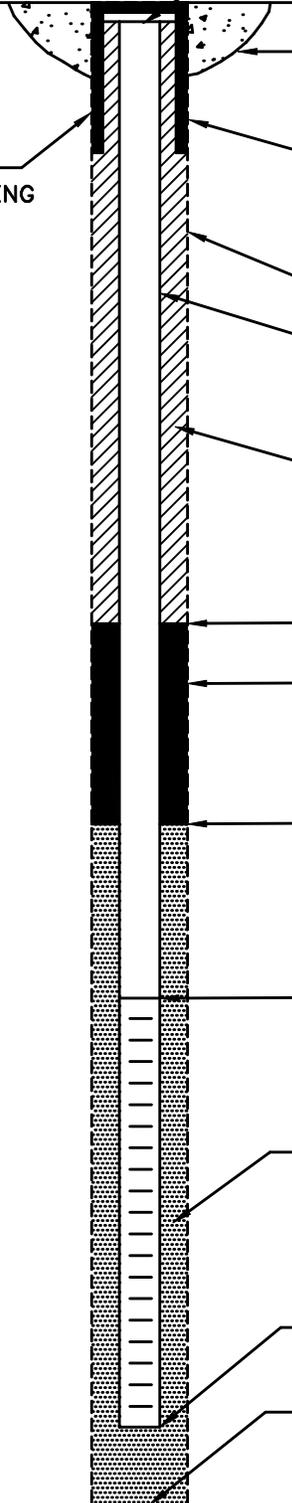
OVERBURDEN MONITORING WELL SHEET FLUSH - MOUNT

WELL NO.: _____

PROJECT _____	LOCATION _____	DRILLER _____
PROJECT NO. _____	BORING _____	DRILLING METHOD _____
DATE BEGUN _____	DATE COMPLETED _____	DEVELOPMENT METHOD _____
FIELD GEOLOGIST _____		
GROUND ELEVATION _____	DATUM _____	

ACAD:FORM_MWFM.dwg 07/20/99 INL

FLUSH MOUNT
SURFACE CASING
WITH LOCK



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: _____



CONTAINER SAMPLE & INSPECTION SHEET

Project Site Name: _____	Sample ID No. _____
Project Number: _____	Sampled By: _____
Site Identification: _____	C.O.C. No.: _____
Container Number(s): _____	Concentration: <input type="checkbox"/> High
Sample Type: <input type="checkbox"/> Grab	<input type="checkbox"/> Medium
<input type="checkbox"/> Composite	<input type="checkbox"/> Low

CONTAINER SOURCE	CONTAINER DESCRIPTION
------------------	-----------------------

DRUM:

Bung Top

Lever Lock

Bolted Ring

Other _____

COLOR: _____

CONDITION: _____

TANK:

Plastic

Metal

Other _____

MARKINGS: _____

VOL. OF CONTENTS: _____

OTHER: _____

OTHER: _____

CONTAINER DISPOSITION	CONTENTS DESCRIPTION
-----------------------	----------------------

SAMPLED: _____

OPENED BUT NOT SAMPLED:
Reason _____

NOT OPENED:
Reason _____

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 or H
% of Total Volume	_____	_____	_____

MONITOR READING:	SAMPLE and /or INSPECTION DATE & TIME:
------------------	--

_____ HRS.

METHOD: _____

SAMPLER(S) and / or INSPECTOR(S) SIGNATURE:	ANALYSIS:
---	-----------



QA SAMPLE LOG SHEET

Project Site Name: _____ Sample ID Number: _____
 Project Number: _____ Sampled By: _____
 Sample Location: _____ C.O.C. Number: _____
 QA Sample Type:
 Trip Blank Rinsate Blank
 Source Water Blank Other Blank _____

SAMPLING DATA: **WATER SOURCE:**

Date: _____
 Time: _____
 Method: _____
 Laboratory Prepared Tap
 Purchased Fire Hydrant
 Other _____

PURCHASED WATER INFORMATION (If Applicable as Source or Rinsate Water): **RINSATE INFORMATION (If Applicable):**

Product Name: _____
 Supplier: _____
 Manufacturer: _____
 Order Number: _____
 Lot Number: _____
 Expiration Date: _____
 Media Type: _____
 Equipment Used: _____
 Equipment Type:
 Dedicated
 Reusable

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected
Volatiles	Cool 4°C & HCl		YES / NO
Semivolatiles	Cool 4°C		YES / NO
Pesticide / PCB	Cool 4°C		YES / NO
Metals	Cool 4°C & HNO ₃		YES / NO
Cyanide	Cool 4°C & NaOH		YES / NO

OBSERVATIONS / NOTES:

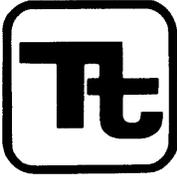
Signature(s):

Tetra Tech NUS, Inc.

PROJECT: _____ LOCATION: _____
 JOB & CTO #: _____ MOBILIZATION DATE: _____
 PROJECT MANAGER: _____ RETURN DATE: _____

FIELD PROJECT DEMOBILIZATION CHECKLIST	
TRAVEL	MISCELLANEOUS
<input type="checkbox"/> Airline reservations <input type="checkbox"/> Hotel reservations/BOQs <input type="checkbox"/> Vehicle rental <input type="checkbox"/> Itinerary <input type="checkbox"/> Phone/pager number	Schedule <input type="checkbox"/> Plan field operations w/ Project manager Documents for Field Program <input type="checkbox"/> Logbook(s) <input type="checkbox"/> Field Sampling plan <input type="checkbox"/> Health & Safety plan <input type="checkbox"/> Maps <input type="checkbox"/> H & S Guidance Manual Authorization <input type="checkbox"/> Kick-off meeting held <input type="checkbox"/> Gov't rate letter <input type="checkbox"/> H&S/OSHA 40-hour certificate <input type="checkbox"/> 8-Hour Refresher Training Certificate <input type="checkbox"/> Medical Clearance Letter <input type="checkbox"/> Supervisory Training Certificate <input type="checkbox"/> Health & Safety Clearance Letter <input type="checkbox"/> Full-size OSHA Poster
DRILLING/DPT/SURVEY	HYDROGEOLOGY EQUIPMENT
Subcontractor <input type="checkbox"/> POC phone #/address <input type="checkbox"/> Drill Specification RFP <input type="checkbox"/> Contact (time & place to meet) <input type="checkbox"/> Confirm subcontract w/ TtNUS Procurement <input type="checkbox"/> Health and Safety documentation for all personnel on site <input type="checkbox"/> Copy of Drillers license <input type="checkbox"/> Well / boring permits Utilities (2 weeks lead time) <input type="checkbox"/> Contact Site POC (Date: _____) <input type="checkbox"/> Contact Local "Call Before You Dig" <input type="checkbox"/> Utility Clearance Form Forms <input type="checkbox"/> Boring logs / Test Pit logs <input type="checkbox"/> Well construction / development forms <input type="checkbox"/> Daily activity forms <input type="checkbox"/> IDW inventory <input type="checkbox"/> IDW drum labels <input type="checkbox"/> Chemical Inventory <input type="checkbox"/> MSDS's	<input type="checkbox"/> Slug test/pumping test forms <input type="checkbox"/> Groundwater elevation data sheets <input type="checkbox"/> Graph paper <input type="checkbox"/> Data Logger/transducer/data cable <input type="checkbox"/> Existing well construction & water level data <input type="checkbox"/> M-Scope, slug
EQUIPMENT MOBILIZATION	SHIPPING
<input type="checkbox"/> Equipment Requisition form completed / equipment ordered <input type="checkbox"/> 3rd Party rental / misc. equipment ordered <input type="checkbox"/> Equipment calibration forms <input type="checkbox"/> Span / calibration gas and regulator	Forms <input type="checkbox"/> FedEx Airbills, local dropoff location & hours <input type="checkbox"/> FedEx Gov. Acct# (1771-8058-0) <input type="checkbox"/> Lab Shipping Labels <input type="checkbox"/> Warehouse Shipping Labels <input type="checkbox"/> Blank Labels Supplies <input type="checkbox"/> Tape <input type="checkbox"/> Packing materials <input type="checkbox"/> Baggies, Large garbage bags
SAMPLING	OTHER
Forms <input type="checkbox"/> Sample log sheets <input type="checkbox"/> Low-flow purge data sheets <input type="checkbox"/> COC records <input type="checkbox"/> COC seals <input type="checkbox"/> Sample labels (from database group) Laboratory <input type="checkbox"/> POC address/phone# <input type="checkbox"/> Order bottles / preservatives <input type="checkbox"/> Shipping address, also check Sat. address <input type="checkbox"/> Bottle & preservation req'ts from lab	<input type="checkbox"/> Site POC name/phone # <input type="checkbox"/> Personnel information to POC <input type="checkbox"/> Mobilization schedule to POC <input type="checkbox"/> Site access authorizations <input type="checkbox"/> Field office / trailer arrangements made <input type="checkbox"/> Electric, phone hookups arranged <input type="checkbox"/> Steel-toed boots, safety glasses, & hard hat <input type="checkbox"/> First aid equipment <input type="checkbox"/> Insect repellent <input type="checkbox"/> _____ <input type="checkbox"/> _____

Note - not all items listed apply to every job, and some additional requirements may apply on a job-specific basis.



TETRA TECH NUS,
INC.

STANDARD OPERATING PROCEDURES

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Effective Date	03/09/09	Revision	2
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	Tom Johnston		

Subject
SAMPLE NOMENCLATURE

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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.

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5.0 PROCEDURES

5.1 INTRODUCTION

The sample identification (ID) system can consist of as few as eight but not more than 20 distinct alphanumeric 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

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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

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- 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.

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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.

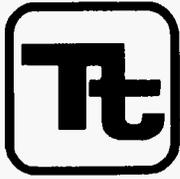
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The first trip blank associated with samples collected on October 12, 2000, would be designated as TB10120001.

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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Applicability Tetra Tech NUS, Inc.	
Prepared Management Information Systems Department	
Approved D. Senovich <i>[Signature]</i>	

Subject
DATABASE RECORDS AND QUALITY ASSURANCE

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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.

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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 Form 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.

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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.

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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

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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: _____ Site Name(s) (Area, OU, etc.): _____ Sampling Date(s): _____ Matrix: <input type="checkbox"/> GW <input type="checkbox"/> SO <input type="checkbox"/> SD <input type="checkbox"/> SW <input type="checkbox"/> Other: _____	Request Date: _____ Date Data Available for Production: _____ Request in Support of: _____ Database Lead: _____ GIS Lead: _____ Statistics Lead: _____ Risk Lead: _____
Labels: <input type="checkbox"/> Labels needed for an upcoming sampling event _____ Total # of Samples _____ Estimated Hours Additional Instructions: _____ _____ Due Date _____ Complete ETS Charge No. _____ _____ FOL _____	
Data Entry: <input type="checkbox"/> Chemical data needs to be entered from hardcopy _____ Estimated # of Samples <input type="checkbox"/> Chemical data needs to be formatted electronically <input type="checkbox"/> Field analytical data needs to be entered from hardcopy <input type="checkbox"/> Geologic data needs to be entered from hardcopy <input checked="" type="checkbox"/> Hydrology data needs to be entered from hardcopy _____ Estimated Hours Additional Instructions: _____ _____ Due Date _____ Complete ETS Charge No. _____	
Tables: <input type="checkbox"/> Full Data Printout <input type="checkbox"/> Summary of Positive Hits <input type="checkbox"/> Occurance and Distribution <input type="checkbox"/> with criteria <input type="checkbox"/> Sampling Analytical Summary <input type="checkbox"/> Other: _____ _____ Estimated Hours Additional Instructions: _____ _____ Due Date _____ Complete ETS Charge No. _____	
GIS: <input type="checkbox"/> General Facility Location <input type="checkbox"/> Site Location <input type="checkbox"/> Potentiometric Contours/Groundwater Flow <input type="checkbox"/> Sample Location Proposed <input type="checkbox"/> Sample Location Existing <input type="checkbox"/> Tag Map Single Round <input type="checkbox"/> Tag Map Multiple Round <input type="checkbox"/> Isoconcentrations <input checked="" type="checkbox"/> Chart Map <input type="checkbox"/> 3D Visualization <input type="checkbox"/> EGIS CD <input type="checkbox"/> Other: _____ _____ Estimated Hours Additional Instructions: _____ _____ Due Date _____ Complete ETS Charge No. _____	
Statistics: <input type="checkbox"/> Yes _____ Estimated Hours Additional Instructions: _____ _____ Due Date _____ Complete ETS Charge No. _____	
Geostatistics: <input type="checkbox"/> Yes _____ Estimated Hours Additional Instructions: _____ _____ Due Date _____ Complete ETS Charge No. _____	



STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Chemistry and Toxicology Department		
Approved	T. Johnston 		

Subject
DATA VALIDATION - CLP ORGANICS FOR SOLID AND AQUEOUS MATRICES

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APPENDIX

A SAMPLE CALCULATIONS

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1.0 PURPOSE

This SOPC governs the validation of data generated by the following methods:

- Gas Chromatography/Mass Spectrometry
 - Volatile Organic Compounds (VOCs) by USEPA CLP Statement of Work (SOW) OLM04.3/OLC03.2/SOM01.1
 - Semivolatile Organic Compounds (SVOCS) by (USEPA CLP Statement of Work (SOW) (OLM04.3/OLC03.2/SOM01.1)
- Gas Chromatography
 - Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs) by USEPA CLP Statement of Work (SOW) OLM04.3/OLC03.2/SOM01.1)

2.0 APPLICABILITY

The applicability of each set of validation criteria is described in the appropriate section below.

3.0 PERSONNEL QUALIFICATIONS

The minimum qualifications of persons implementing this SOP are as follow:

- Education – Minimum of a bachelor's degree in chemistry or related physical/life science.
- Experience requirements include either operational experience with the analytical method or method data review training conducted under the direction of an experienced reviewer and performed on the subject matter data package. A record of the training will not be documented and kept on file but the data validation report produced under training will serve as the record.

4.0 CLP ORGANICS BY GC/MS

4.1 Volatiles (USEPA CLP Statement of Work (SOW) OLM04.3/OLC03.2/SOM01.1)

4.1.1 Applicability

CLP volatile methodology is used to determine organic compounds in most matrices including groundwater, sludges, caustic liquors, acid liquors, waste solvents, oily wastes, pastes, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments.

The CLP volatile Target Compound List (TCL) consists of the following compounds:

Acetone	1,4-Dichlorobenzene	Methyl Acetate
Benzene	1,2-Dibromo-3-Chloropropane	Methylcyclohexane
Bromodichloromethane	Dibromochloromethane	Methylene Chloride
Bromoform	Dichlorodifluoromethane	4-Methyl-2-Pentanone
Bromomethane	1,2-Dibromoethane	Methyl-t-butyl ether (MTBE)

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2-Butanone	1,1-Dichloroethane	Styrene
Carbon Disulfide	1,2-Dichloroethane	1,1,2,2-Tetrachloroethane
Carbon Tetrachloride	1,1-Dichloroethene	Tetrachloroethene
Chlorobenzene	1,2-Dichloroethene (total)	Toluene
Chlorobromomethane	1,2-Dichloropropane	Trichlorofluoromethane
Chloroethane	cis-1,2-Dichloroethene	1,1,2-Trichloro-1,2,2-Trifluoroethane
Chloroform	cis-1,3-Dichloropropene	1,2,3-Trichlorobenzene
Chloromethane	trans-1,2-Dichloroethene	1,2,4-Trichlorobenzene
Cyclohexane	trans-1,3-Dichloropropene	1,1,1-Trichloroethane
1,2-Dibromoethane (EDB)	Ethyl Benzene	1,1,2-Trichloroethane
1,2-Dichlorobenzene	2-Hexanone	Trichloroethene
1,3-Dichlorobenzene	Isopropylbenzene	Vinyl Chloride
		Xylenes (total)

This method is based upon a purge-and-trap, gas chromatographic/mass spectrometric (GC/MS) procedure. Prior to analysis, samples must be prepared according to the SOW.

4.1.2 Interferences

Samples can be contaminated by diffusion of volatile organics (particularly chlorofluorocarbons and methylene chloride) through the sample container septum during shipment and storage. Associated field quality control blanks are analyzed in order to monitor this.

Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe or purging device is rinsed with reagent water between samples. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of reagent water to check for cross contamination.

If sample or matrix interferences are encountered, a secondary or alternate analytical column may be used to resolve the compounds of interest.

4.1.3 General Laboratory Practices

A method blank consisting of organic free water spiked with surrogates and internal standards should be analyzed immediately following each daily calibration, and also after the analysis of every high concentration sample.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analyses should be conducted to determine the effects of sample matrix upon the compounds of interest.

4.1.4 Sample Preparation

A purge-and-trap procedure is performed to prepare and extract volatile compounds from samples and to introduce those compounds into the GC/MS.

For highly volatile matrices, direct injection preceded by dilution should be used to prevent gross contamination of the instrumentation. For pastes, dilution of the sample until it becomes free-flowing is used to ensure adequate interfacial area. The success of this method depends on the level of interferences in the sample; results may vary due to the large variability and complicated matrices of solid waste samples.

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4.1.5 Data Overview Prior to Validation

Before commencing validation, preview the associated Chain-of-Custody (COC) reports to determine:

- a. If the appropriate numbers of samples are present in the data package and if each sample was correctly analyzed for the parameters and methods specified.
- b. The identity of all associated field quality control blanks and field duplicate pairs.

NOTE: Unless specifically directed by client protocol, never annotate the laboratory data package.

- c. Prepare working copies (i.e., photocopies) of all Form I reports (including those for samples, laboratory method blanks and MS/MSD analyses), and all laboratory quality control summary forms (including all initial and continuing calibration summary statistics).

4.1.6 Technical Evaluation Summary

Conduct all data evaluations in accordance with applicable USEPA Regional protocols and/or specific client contract requirements. Reference the applicable documents during the data evaluation process as this S.O.P. is only intended as a general procedure for the data validation tasks.

Evaluate general parameters such as Data Completeness, Overall System Performance, Chromatographic Quality, Detection Limits and Compound Identification concurrently with the parameters discussed in the following subsections.

4.1.6.1 Holding Times and Sample Preservation Criteria

Verify that holding times are evaluated by reviewing the COC reports, the individual sample Form I reports, and the associated laboratory raw data. Calculate holding times from date of collection to date of analysis. Verify that samples are stored according to method requirements. Use the following rules:

- a. For unpreserved aqueous samples, apply a 7-day maximum holding time allowance for aromatic compounds, and with a 14-day maximum holding time allowance for chlorinated hydrocarbons.
- b. For aqueous samples preserved with hydrochloric acid (HCl) to pH 2 or below, apply a 14-day maximum holding time as the technical maximum holding time allowance .
- c. For soil samples in proper containers, apply a 14-day maximum holding time allowance.
- d. Verify that all samples were stored at 4°C ± 2 °C.

4.1.6.2 Holding Time and Sample Preservation Action

- a. If maximum holding times are exceeded, qualify positive results in affected samples as estimated (J); and qualify nondetects as not detected/estimated (UJ). These results are usually assumed to be biased low unless prolonged storage causes a concentration increase, e.g., for degradation products which are also target analytes.
- b. If holding times are exceeded by a factor of more than two times the maximum holding time, qualify positive results as estimated (J); and qualify nondetects as rejected (UR). These exceedances are considered to be gross holding time exceedances.

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- c. If EPA Regional requirements apply, as in EPA Region III, apply the appropriate bias qualifiers as required; for example, detections and nondetects as biased low (L) or (UL), respectively.
- d. If samples are received above the required temperature, use professional judgment in applying qualifiers. Consider the length of time in storage, the inferred holding temperature, and other factors that could affect the target analyte concentrations.

4.1.6.3 GC/MS Tuning Criteria

An analysis of an instrument performance check standard of Bromofluorobenzene must be performed at the beginning of each 12-hour period in which samples and standards are being analyzed.

- a. Verify that all ion abundance criteria below are within acceptance ranges on Form V or equivalent summary form:

m/z	Ion abundance criteria
50	8.0 – 40.0% of m/z 95
75	30.0 – 66.0% of m/z 95
95	Base peak, 100%
96	5.0 – 9.0% of m/z 95
173	Less than 2.0% of m/z 174
174	50.0 – 120.0% of m/z 95
175	5.0 – 9.0% of m/z 174
176	93.0 – 101.0% of m/z 174
177	5.0 – 9.0% of m/z 176

- b. Verify that all samples and standards were analyzed within the 12-hour period.

4.1.6.4 GC/MS Tuning Action

- a. If mass assignment is in error, then reject all associated data (R) or (UR).
- b. If ion abundance criteria are not met, professional judgment may be used to determine the extent of data usability and whether qualifications are needed. The most critical abundances are m/z 95/96, 174/175, 174/176, and 176/177.
- c. If samples were analyzed beyond the 12-hour period, then qualify positive and nondetected results as estimated, (J) and (UJ) respectively.
- d. If the reviewer suspects that improper background subtraction techniques were used to generate a compliant tune, contact the laboratory and ask them to provide supporting evidence of tuning data. If the evidence is suitable, no further action is required. If proper evidence cannot be provided to support the tuning data, then professional judgment should be utilized to determine the usability of the associated data.

4.1.6.5 Calibration Criteria

Verify the following:

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- a. Verify that an initial calibration was performed for each instrument used for analysis and for each type of medium and that all calibrations were performed at all appropriate concentration levels within 12 hours of the associated instrument tuning.
- b. Verify that a continuing calibration was performed for each instrument used for analysis, for each type of medium, and that the continuing calibration was performed following the instrument tune.
- c. Review initial calibration Form VIs and the associated laboratory raw data to determine which compounds have:
 - 1) Average Relative Response Factors (RRFs) <0.050
 - 2) Percent Relative Standard Deviations (%RSDs) >30%.
- d. Circle noncompliant RRFs and %RSDs on your working copies of these Forms and spot-check (i.e., recalculate) a few of the RRFs and %RSDs to verify the laboratory's computation.
- e. Determine which samples are affected by non-compliant RRFs or %RSDs by reviewing the continuing calibration Form VIIs. Check the instrument identification and the initial calibration date(s) noted in the headings of the Form VIIs to determine which continuing calibrations are associated with which initial calibrations.
- f. Review the sample listings given on the data package Form Vs to match the indicated continuing calibration run with the appropriate Form VII by matching the laboratory file ID numbers.
- g. Review the continuing calibration Form VIIs and the associated laboratory raw data to determine which compounds have:
 - 1) RRFs <0.050
 - 2) Percent Differences (%Ds) >25%
- h. Circle the noncompliant RRFs and %Ds on your working copies of these Forms and spot-check (i.e., recalculate) a few of the RRFs and %Ds to verify the laboratory's computation.
- i. For samples analyzed by OLC03.2, review the initial calibration and verify that the RRFs are greater than or equal to 0.010 for the compounds in Table 1 and are >0.050 for all other compounds:
- j. Review the initial calibration associated with OLC03.2 and verify that the %RSD is < 50% for the compounds in Table 1 and <30% for all other compounds:

Table 1
Volatile Compounds Exhibiting Poor Response

Acetone	1,2-Dichloropropane
2-Butanone	1,2-Dibromo-3-chloropropane
Carbon Disulfide	4-Methyl-2-pentanone
Chloroethane	2-Hexanone
Chloromethane	Cyclohexane

- k. Review the continuing calibration associated with OLC03.2 and verify that the %Ds are < 50% for the compounds in Table 1 and <30% all other compounds.

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4.1.6.6 Calibration Actions

- a. If any RRFs are <0.050, qualify all affected positive as estimated (J); qualify nondetects as nondetected rejected (UR). In accordance with some USEPA Regional protocol, the (L) qualifier may be used instead of (J) when qualifying positive results. Bias for these results is very low.
- b. If any %RSD exceeds 30%, qualify affected positive results as estimated (J); qualify nondetects as nondetected estimated (UJ). Check the specific applicable data validation protocol for further guidance as there are some protocols which only estimate nondetects if the %RSD is >50% or reject nondetects if the %RSD is excessive (e.g. >90%). Bias for these results cannot be determined.
- c. If any %D exceeds 25%, qualify affected positive results as estimated (J); qualify nondetects as nondetected estimated (UJ). Check the specific applicable data validation protocol for further guidance as there are some protocols which only estimate nondetects if the %D is >50% or reject nondetects if the %RSD is excessive (e.g. >90%). Bias for these results cannot be determined.
- d. If any OLC03.2 compounds in Table 1 contain RRFs are <0.010 and if any other compounds are <0.050, qualify affected positive results as estimated (J); qualify nondetects as nondetected rejected (UR). In accordance with some USEPA Regional protocol, the (L) qualifier may be used instead of (J) when qualifying positive results. Bias for these results is very low.
- e. If any OLC03.2 compounds in Table 1 are > 50% RSD and >30% for all other compounds, qualify affected positive results as estimated (J); qualify nondetects as nondetected estimated (UJ).
- f. If any OLC03.2 compounds in Table 1 are >50% D and >30% for all other compounds, qualify affected positive results as estimated (J); qualify nondetects as nondetected estimated (UJ).

4.1.6.7 Blank Contamination Criteria

When using the information given below and in the appropriate USEPA Regional Functional Guidelines, keep in mind that the validation action levels derived are sample specific and must be adjusted for dilution, sample aliquot used for analysis, and sample moisture content (when applicable).

The rules for qualifying data based on the occurrence of blank contamination vary based on regional protocols. The guidelines provided in the appropriate protocol should be followed. Verify the following:

- a. A method or laboratory preparation blank must be analyzed during each 12-hour period.

The method blank should be free of contamination.

4.1.6.8 Blank Contamination Action

- a. If a target compound is detected in any method blank:
 - 1) Select the maximum concentration of a particular contaminant occurring in the laboratory method blanks. (Do not consider lab blanks run after high concentration samples for purposes of determining carryover as laboratory method blanks!)
 - 2) Establish action levels for qualification (10X or 5X the maximum contaminant concentration depending upon whether or not the contaminant is a common contaminant). Common laboratory contaminants include methylene chloride, acetone, 2-butanone, and cyclohexane.

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3) Raise positive results that are less than the established blank action level to the Contract Required Quantitation Limit (CRQL) and qualify them as nondetect (U). In accordance with some USEPA Regional protocol, the (B) qualifier may be used instead of (U) when qualifying positive results. In this case, qualify the results at the concentration detected instead of the CRQL.

- b. If a target compound was detected in a field quality control blank, carefully evaluate the associated samples to determine the appropriate action. Typically, field quality control blanks are not used to establish blank action levels but professional judgment may be used. When the reviewer decides to use a field quality control blank to qualify associated environmental samples, the guideline above must be followed.

4.1.6.9 Surrogates Criteria

- a. Evaluate surrogate recoveries by reviewing the laboratory data package Form II reports and the laboratory raw data.
- b. Verify that the recoveries are within the quality control ranges as given on the laboratory data package Form IIs; circle any noncompliances on your working copies of these Forms.

4.1.6.10 Surrogate Action

- a. If one or more surrogate recoveries exceed the upper quality control limit, qualify positive results as estimated (J); do not qualify Nondetects. A bias qualifier may be used in certain Regions. In accordance with some USEPA Regional protocol, the (K) qualifier may be used instead of (J) when qualifying positive results
- b. If one or more surrogate recoveries are below the lower quality control limit but are >10%, qualify positive and nondetected results as estimated (J) or nondetected estimated (UJ), respectively. These results are biased low. A bias qualifier may be used in certain Regions. In accordance with some USEPA Regional protocol, the (L, UL) qualifiers may be used instead of (J, UJ) when qualifying results
- c. If any surrogate recovery is <10%, qualify positive results as estimated (J); qualify nondetects as rejected (UR). These results are biased very low. The bias qualifiers (L, UL) may be used instead, depending upon the specific USEPA Regional guidance.
- d. For OLC03.2 analyses, if a recovery is greater than the upper control limit, qualify positive results associated with that surrogate as estimated (J); do not qualify nondetects.
- e. For OLC03.2 analyses, if a recovery is greater than 20% but less than the lower quality control limit, qualify positive and nondetected results associated with that surrogate as estimated (J) or nondetected estimated (UJ), respectively.
- f. For OLC03.2 analyses, if a recovery is <20%, qualify positive results associated with that surrogate as estimated (J) and qualify nondetects as nondetected rejected (UR).

4.1.6.11 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Criteria

Verify that matrix spike and matrix spike duplicate recoveries and Relative Percent Differences (RPD) meet quality control limits. Circle outliers on the Form III or equivalent.

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4.1.6.12 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Action

- a. No action is generally taken on MS/MSD noncompliances alone.
- b. If a matrix spike or matrix spike duplicate recovery is <10%, qualify positive results as estimated (J) and qualify nondetects as nondetected rejected (UR) in the unspiked sample.

4.1.6.13 Internal Standard Criteria

Evaluate internal standards by reviewing the data package Form VIIIs and the laboratory raw data. Verify the following:

- a. Internal standard areas fall within -50% or +100% for a given internal standard.
- b. For OLC03.2, internal standard areas fall within $\pm 40\%$ a given internal standard.
- c. Retention times do not vary by more than ± 30 seconds.
- d. For OLC03.2, retention times do not vary by more than ± 20 seconds.

4.1.6.14 Internal Standard Action

- a. If the area count is > +100%, qualify positive results associated with a given internal standard as estimated (J); do not qualify nondetects.
- b. If the area count is < -50%, qualify positive and nondetected results associated with a given internal standard as estimated (J) or nondetected estimated (UJ), respectively.
- c. For OLC)3.2, if the area count is > +40%, qualify positive results associated with a given internal standard as estimated (J); do not qualify nondetects.
- d. For OLC03.2, if the area count is < -40%, qualify positive and nondetected results associated with a given internal standard as estimated (J) or nondetected estimated (UJ), respectively.
- e. If the retention time varies by more than ± 30 seconds carefully evaluate results, especially nondetected results. If deviations are severe, qualify the associated results as nondetected rejected (UR).
- f. For OLC03.2, if the retention time varies by more than ± 20 seconds carefully evaluate results, especially nondetected results. If deviations are severe, qualify the associated results as nondetected rejected (UR).

4.1.6.15 Tentatively Identified Compounds (TICs) Criteria

Verify that the laboratory reported TICs in the laboratory data package Form I VOA-TIC reports and the laboratory raw data.

4.1.6.16 Field Duplicate Precision Criteria

- a. Check samples to determine if field duplicates were included in the data package.

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- b. The Relative Percent Difference (RPD) between field duplicate results for the aqueous matrix should be <30%; for soil matrix results, <50% for sample results greater than the reporting limit.

4.1.6.17 Field Duplicate Precision Action

- a. If positive results are greater than the reporting limit, qualify positive results for aqueous or soil media if the RPD exceeds 30% or 50% respectively. Qualification of the sample data is limited to the specific field duplicate pair. Qualify positive results showing imprecision as estimated (J) Bias for these results cannot be determined.
- b. If one result is positive and the other is nondetected and the positive result is greater than 2 times the reporting limit, qualify positive and nondetected results as estimated (J) or nondetected estimated (UJ), respectively.

4.1.6.18 Sample Result Verification Criteria

- a. Verify and record the quantitation of at least one compound per analytical fraction. If no positive results are reported, use the MS/MSD data to confirm proper computation by the laboratory. Validator and laboratory quantitations must agree within 10 percent.

4.1.6.19 Sample Result Verification Action

- a. Perform a calculation verification of at least one analyte per fraction and include the re-calculation results in the support documentation section of the validation report. See Appendix A for calculation procedure.
- b. If the re-calculation does not agree with the laboratory result within 10%, contact the laboratory to determine whether the reviewer may have used incorrect information or if the laboratory result is incorrect and requires resubmission. A comment on the final outcome is required in the validation report along with the proper calculation verification.

4.1.6.20 Percent Solids Criteria

- a. Check the percent solids for each sample to identify any samples that contain <30% solids.

4.1.6.21 Percent Solids Action

- a. If any sample contains <30% solids, qualify positive and nondetected results as estimated (J) or nondetected estimated (UJ), respectively, due to the high moisture content of the sample.
- b. If any sample contains <10% solids, qualify positive results as estimated (J); qualify nondetected results as rejected (UR).

4.1.7 Deliverables Guidance

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for Data Validation

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Quality Assurance Officer (DV/QAO) review.

4.2 Semivolatiles (USEPA CLP Statement of Work (SOW) (OLM04.3/OLC03.2/SOM01.1)

4.2.1 Applicability

CLP semivolatile methodology is applicable to nearly all types of samples, regardless of water content, including groundwater, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, pastes, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments.

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The semivolatile TCL includes the following compounds:

Acenaphthene	2,2'-oxybis(1-Chloropropane)	Hexachlorocyclopentadiene
Acenaphthylene	Chrysene	Hexachloroethane
Acetophenone	Dibenzo(a,h)anthracene	Indeno(1,2,3-cd)pyrene
Anthracene	Dibenzofuran	Isophorone
Atrazine	3,3'-Dichlorobenzidine	2-Methylnaphthalene
Benzaldehyde	2,4-Dichlorophenol	2-Methylphenol
Benzo(a)anthracene	Diethylphthalate	4-Methylphenol
Benzo(b)fluoranthene	2,4-Dimethylphenol	Naphthalene
Benzo(k)fluoranthene	Dimethylphthalate	2-Nitroaniline
Benzo(g,h,i)perylene	Di-n-butylphthalate	3-Nitroaniline
Benzo(a)pyrene	4,6-Dinitro-2-methylphenol	4-Nitroaniline
1,1'-Biphenyl	2,4-Dinitrophenol	Nitrobenzene
4-Bromophenyl-phenylether	2,4-Dinitrotoluene	2-Nitrophenol
Butylbenzylphthalate	2,6-Dinitrotoluene	4-Nitrophenol
Caprolactum	Di-n-octylphthalate	N-Nitroso-di-n-propylamine
Carbazole	bis(2-Ethylhexyl)phthalate	N-Nitroso-diphenylamine
4-Chloroaniline	Fluoranthene	Pentachlorophenol
bis(2-Chloroethoxy)methane	Fluorene	Phenanthrene
bis(2-Chloroethyl)ether	Hexachlorobenzene	Phenol
4-Chloro-3-methylphenol	Hexachlorobutadiene	Pyrene
2-Chloronaphthalene		1,2,4,5-Tetrachlorobenzene
2-Chlorophenol		2,4,5-Trichlorophenol
4-Chlorophenyl-phenylether		2,4,6-Trichlorophenol

The preceding method is based upon solvent extractions followed by gas chromatographic/mass spectrometric (GC/MS) procedures.

4.2.2 Interferences

Solvents, reagents, glassware, and other sample processing hardware may yield discrete artifacts that cause elevated baselines and lead to potential misinterpretation of chromatograms. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by running method blanks. The use of high purity reagents and solvents helps to minimize interference problems; purification of solvents by distillation in all-glass systems may be required.

Interferences co-extracted from the samples will vary considerably from source to source depending upon the diversity of the industrial complex or waste being sampled.

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4.2.3 General Laboratory Practices

An extraction blank should be prepared with each batch of samples extracted.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analyses should be conducted once per 20 samples of a similar matrix to determine the effects of sample matrix upon the compounds of interest.

4.2.4 Sample Preparation

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Prior to GC/MS analysis, aqueous samples are acidified to pH 2 and extracted with methylene chloride using a continuous liquid-liquid extractor. Both neat and diluted organic liquids may be analyzed by direct injection. Solid samples are extracted with 1:1 methylene chloride/acetone using a sonication procedure. Cleanup by Gel Permeation Chromatography (GPC) is required for solid sample extracts.

4.2.5 Data Overview to Validation

Before commencing validation, preview the associated Chain-of-Custody (COC) reports to determine:

- a. If the appropriate numbers of samples are present in the data package and if each sample was correctly analyzed for the parameters and methods specified.
- b. The identity of all associated field quality control blanks and field duplicate pairs.

NOTE: Unless specifically directed by client protocol, never annotate the laboratory data package.

- c. Prepare working copies of all Form I reports (including those for samples, laboratory method blanks, and MS/MSD analyses) and all laboratory quality control summary forms (including all initial and continuing calibration summary statistics).

4.2.6 Technical Evaluation Summary

Conduct all data evaluations in accordance with the appropriate USEPA Regional protocols (when applicable) and/or specified client contract requirements. Reference the applicable documents during the data validation process as this S.O.P. is only intended as a general procedure for all data validation tasks.

Evaluate general parameters such as Data Completeness, Overall System Performance, Chromatographic Quality, Detection Limits and Compound Identification concurrently with the parameters discussed in the following subsections.

4.2.6.1 Holding Times and Sample Preservation Criteria

Verify that holding times are evaluated by reviewing the COC reports, the individual sample Form I reports, and the associated laboratory raw data. Calculate holding times for extraction from date of collection to date of extraction. Verify that samples are stored to method requirements. Use the following rules:

- a. For aqueous samples, use a 7-day maximum holding time until extraction.
- b. For soil samples, use a 14-day maximum holding time until extraction.

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- c. For sample extracts use a holding time of 40 days from date of extraction to analysis.
- d. Verify that all samples were stored at 4°C ± 2 °C prior to extraction.
- e. Verify that all extracts were stored at 4°C ± 2 °C.

4.2.6.2 Holding Times and Sample Preservation Action

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- a. If holding times are exceeded, qualify positive results in affected samples as estimated (J); qualify nondetects as nondetected estimated(UJ). These results are usually assumed to be biased low unless prolonged storage causes a concentration increase, e.g., for degradation products which are also target analytes.
- b. If holding times are exceeded by a factor of more than two times the required time, qualify positive results as estimated (J); qualify nondetects as nondetected rejected (UR). These exceedances are considered to be gross holding time exceedances.
- c. If EPA Regional requirements apply, as in EPA Region III, apply the appropriate bias qualifiers as required; for example, detections and as nondetects biased low (L) or (UL), respectively.
- d. If samples are received above the required temperature, use professional judgment in applying qualifiers. Consider the length of time in storage, the inferred holding temperature, and other factors that could affect the target analyte concentrations.

4.2.6.3 GC/MS Tuning Criteria

An analysis of an instrument performance check standard of Decafluorotriphenylphosphine (DFTPP) must be performed at the beginning of each 12-hour period in which samples and standards are being analyzed.

- a. Verify that all ion abundance criteria below are within acceptance ranges on Form V or equivalent summary form:

m/z	Ion abundance criteria
51	30.0 – 80.0% of m/z 198
68	Less than 2.0% of m/z 198
69	Mass 69 relative abundance
70	Less than 2.0% of m/z 69
127	25.0 – 75.0% of m/z 198
197	Less than 1.0% of m/z 198
198	Base Peak 100%
199	5.0 – 9.0% of m/z 198
275	10.0 – 30.0% of m/z 198
365	Greater than 0.75% of m/z 198
441	Present, but less than m/z 443
442	40.0 – 110.0% of m/z 198
443	15.0 – 24.0% of m/z 442

- b. Verify that all samples and standards were analyzed within the 12-hour period.

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4.2.6.4 GC/MS Tuning Action

- a. If mass assignment is in error, then reject all associated data (R) or (UR).
- b. If ion abundance criteria are not met, professional judgment may be used to determine the extent of data usability and whether qualifications are needed. The most critical abundances are m/z 199/198 and 442/443.
- c. If the relative abundance of m/z 365 is low or is zero this is an indication of an unsuitable instrument zero. Detection limits may be affected and nondetected results should be qualified (UJ).
- d. If samples were analyzed beyond the 12-hour period, then ^{TD} positive and nondetected results as estimated, (J) and (UJ) respectively. ^{4/27/11}
- e. If the reviewer suspects that improper background subtraction techniques were used to generate a compliant tune, contact the laboratory and ask them to provide supporting evidence of tuning data. If the evidence is suitable, no further action is required. If proper evidence cannot be provided to support the tuning data, then professional judgment should be utilized to determine the usability of the associated data.

4.2.6.5 Calibration Criteria

Verify the following:

- a. Verify that an initial calibration was performed for each instrument used for analysis and that all calibrations were performed at all appropriate concentration levels within 12 hours of the associated instrument tuning.
- b. Verify that a continuing calibration was performed for each instrument used for analysis and that the continuing calibration was performed following the instrument tune.
- c. Review initial calibration Form VIs and the associated laboratory raw data to determine which compounds have:
 - 1) Average Relative Response Factors (RRFs) <0.050
 - 2) Percent Relative Standard Deviations (%RSDs) >30%.
- d. Circle these noncompliant RRFs and %RSDs on your working copies of these Forms and spot-check (i.e., recalculate) a few of the RRFs and %RSDs to verify the laboratory's computation.
- e. Determine which samples are affected by non-compliant RRFs or %RSDs by reviewing the continuing calibration Form VIIs. Check the instrument identification and the initial calibration date(s) noted in the headings of the Form VIIs to determine which continuing calibrations are associated with which initial calibrations. Next, review the sample listings given on the data package Form Vs. Match the indicated continuing calibration run with the appropriate Form VII by matching the laboratory file ID numbers.
- f. Review the continuing calibration Form VIIs and the associated laboratory raw data to determine which compounds have:
 - 1) RRFs <0.050
 - 2) Percent Differences (%Ds) >25%

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- g. Circle the noncompliant RRFs and %Ds on your working copies of these Forms and spot-check (i.e., recalculate) a few of the RRFs and %Ds to verify the laboratory's computation.
- h. For samples analyzed by OLC03.2, review the initial calibration and verify that the RRFs are greater than or equal to 0.010 for the compounds in Table 2 and are >0.050 for all other compounds:
- i. Review the initial calibration associated with OLC03.2 and verify that the %RSDs are < 50% for the compounds in Table 2, <30% for 2,4-dinitrotoluene, 2-nitrophenol, and 2,4-dimethylphenol, and <20.5% for all other compounds.

Table 2 TD
Semivolatile Compounds Exhibiting Positive Bias 4/27/11

2,2'-oxybis(1-Chloropropane)	Benzaldehyde
4-Chloroaniline	Pentachlorophenol
Hexachlorobutadiene	4-Nitroaniline
Hexachlorocyclopentadiene	4,6-Dinitro-2-methylphenol
2-Nitroaniline	N-Nitroso-diphenylamine
3-Nitroaniline	3,3'-Dichlorobenzidine
2,4-Dinitrophenol	4-Nitrophenol
Acetophenone	Caprolactum

- j. Review the continuing calibration associated with OLC03.2 and verify that the %Ds are ≤ 50% for the following compounds in Table 2, ≤30% for 2,4-dinitrotoluene, 2-nitrophenol, and 2,4-dimethylphenol, and ≤25.0% for all other compounds.

4.2.6.6 Calibration Actions

- a. If any RRFs are <0.050, qualify all affected positive results as estimated (J); qualify nondetects as nondetected rejected (UR). In accordance with some USEPA Regional protocol, the (L) qualifier may be used instead of (J) when qualifying positive results. Bias for these results is very low.
- b. If any %RSD exceeds 30%, qualify all affected positive results as estimated (J); qualify nondetects as nondetected estimated (UJ). Check the specific applicable data validation protocol for further guidance as there are some protocols which only estimate nondetects if the %RSD is >50% or reject nondetects if the %RSD is excessive (e.g. >90%). Bias for these results cannot be determined.
- c. If any %D exceeds 25%, qualify all affected positive results as estimated (J); qualify nondetects as nondetected estimated (UJ). Check the specific applicable data validation protocol for further guidance as there are some protocols which only estimate nondetects if the %D is >50% or reject nondetects if the %RSD is excessive (e.g. >90%). Bias for these results cannot be determined.
- d. If any OLC03.2 compounds in Table 2 contain RRFs are <0.010 and if any other compounds are <0.050 qualify affected positive results as estimated (J); qualify nondetects as rejected (UR). In accordance with some USEPA Regional protocol, the (L) qualifier may be used instead of (J) when qualifying positive results. Bias for these results is very low.
- e. If any OLC03.2 compounds in Table 2 contain %RSDs that are > 50%, >30% for 2,4-dinitrotoluene, 2-nitrophenol, and 2,4-dimethylphenol, and >20.5% for all other compounds. qualify affected positive results as estimated (J); qualify nondetects as nondetected estimated (UJ).

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- f. If any OLC03.2 compounds in Table 2 contain %Ds that are >50% >30% for 2,4-dinitrotoluene, 2-nitrophenol, and 2,4-dimethylphenol, and >25.0% for all other compounds, qualify positive results as estimated (J); qualify nondetects as nondetected estimated (UJ).

4.2.6.7 Blank Contamination Criteria

When using the information given below and in the appropriate USEPA Regional Functional Guidelines, keep in mind that the validation action levels derived are sample specific and must be adjusted for dilution, sample aliquot used for analysis, and sample moisture content (when applicable).

The rules for qualifying data based on the occurrence of blank contamination vary based on regional protocols. The guidelines provided in the appropriate protocol **TD** followed. Verify the following:

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- A method or laboratory preparation blank must be analyzed each 12-hour period.
- The method blank should be free of contamination.
- Note that unlike volatile fraction analyses, a laboratory method blank does not have to be analyzed after every continuing calibration standard. Be very sure, however, that one semivolatile method blank was extracted for each day that associated samples were extracted (with a maximum of 20 samples per batch).

4.2.6.8 Blank Contamination Action

- If a target compound is detected in any method blank:
 - Select the maximum concentration of a particular contaminant occurring in the laboratory method blanks. (Do not consider lab blanks run after high concentration samples for purposes of determining carryover as laboratory method blanks!)
 - Establish action levels for qualification (10X or 5X the maximum contaminant concentration depending upon whether or not the contaminant is a common contaminant).. Common laboratory contaminants include phthalates. For method OLC03.2, the action level is 5 times the maximum contaminant concentration for phthalates.
 - Raise positive results that are less than the established blank action level to the Contract Required Quantitation Limit (CRQL) and qualify them as nondetect (U). In accordance with some USEPA Regional protocol, the (B) qualifier may be used instead of (U) when qualifying positive results. In this case, qualify results at the concentration detected instead of the CRQL.
- If a target compound was detected in a field quality control blank, carefully evaluate the associated samples to determine the appropriate action. Typically, field quality control blanks are not used to establish blank action levels but professional judgment may be used. When the reviewer decides to use a field quality control blank to qualify associated environmental samples, the guideline above must be followed.

4.2.6.9 Surrogates Criteria

Semivolatile compounds are divided into two fractions, base-neutral compounds and acid-extractable compounds. Each fraction of compounds has its own associated surrogates. Phenolic compounds are included in the acid fraction and all remaining compounds are included in the base-neutral fraction.

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Evaluate surrogate recoveries by reviewing the laboratory data package Form II reports and the laboratory raw data.

Verify that the recoveries are within the quality control ranges as given on the laboratory data package Form IIs; circle any noncompliances on your working copies of these Forms.

4.2.6.10 Surrogate Action

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- a. If two or more surrogate recoveries for a given fraction exceed the upper quality control limit, qualify positive results in that fraction as estimated (J); do not qualify nondetects. A bias qualifier may be used in certain Regions. In accordance with some USEPA Regional protocol, the (K) qualifier may be used instead of (J) when qualifying positive results
- b. If two or more surrogate recoveries for a given fraction are below the lower quality control limit but are >10%, qualify positive and nondetected results in the associated fraction as estimated (J) or nondetected estimated, respectively(UJ). These results are biased low. A bias qualifier may be used in certain Regions. In accordance with some USEPA Regional protocol, the (L,UL) qualifiers may be used instead of (J, UJ) when qualifying results
- c. If any surrogate recovery is <10% in a given fraction, qualify positive results in that fraction as estimated (J); qualify nondetects as nondetected rejected (UR). These results are biased very low. The bias qualifiers (L, UL) may be used instead, depending upon the specific USEPA Regional guidance.
- d. For OLC03.2 analyses, if a surrogate recovery is greater than the upper control limit, qualify positive results associated with that surrogate as estimated (J); do not qualify nondetects qualified.
- e. For OLC03.2 analyses, if a surrogate recovery is less than the lower quality control limit, qualify positive and nondetected results associated with that surrogate as estimated (J) or nondetected estimated (UJ), respectively.
- f. For OLC03.2 analyses, if a recovery is <10%, qualify positive results associated with that surrogate as estimated (J) and qualify nondetects as rejected (UR).

4.2.6.11 Matrix Spike/Matrix Spike Duplicate Criteria

Verify that matrix spike and matrix spike duplicate recoveries and Relative Percent Differences (RPD) meet quality control limits. Circle outliers on the Form III or equivalent.

4.2.6.12 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Action

- a. Take no action based on MS/MSD noncompliances alone.
- b. If a matrix spike or matrix spike duplicate recovery is <10%, qualify positive results in the unspiked sample as estimated (J) and qualify nondetects as nondetected rejected (UR) sample.

4.2.6.13 Internal Standard Criteria

Evaluate internal standards are evaluated by reviewing the data package Form VIIIs and the laboratory

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raw data. Verify the following:

- a. Internal standard areas fall within -50% or +100% for a given internal standard.
- b. Retention times do not vary by more than ± 30 seconds.

4.2.6.14 Internal Standard Action

- a. If the area count is $> +100\%$, qualify positive results associated ~~with~~ ^{TD} ~~an~~ ^{4/27/11} internal standard as estimated (J); do not qualify nondetects.
- b. If the area count is $< -50\%$, qualify positive and nondetected results associated with a given internal standard as estimated (J) or nondetected estimated (UJ), respectively.
- c. If the retention time varies by more than ± 30 seconds carefully evaluate results, especially nondetected results. If deviations are severe, qualify the associated results as nondetected rejected (UR).

4.2.6.15 Tentatively Identified Compounds (TICs)

Verify that the laboratory reported TICs in the laboratory data package Form I SVOA-TIC reports and the laboratory raw data.

4.2.6.16 Field Duplicate Precision Criteria

- a. Check samples to determine if field duplicates were included in the data package.
- b. The Relative Percent Difference (RPD) between field duplicate results for the aqueous matrix should be $< 30\%$; for soil matrix results, $< 50\%$ for sample results greater than the reporting limit.

4.2.6.17 Field Duplicate Precision Action

- a. If positive results are greater than the reporting limit, qualify positive results for aqueous or soil media if the RPD exceeds 30% or 50% respectively. Qualification of the sample data is limited to the specific field duplicate pair. Qualify positive results for compounds showing imprecision are qualified as estimated (J) Bias for these results cannot be determined.
- b. If one result is positive and the other is nondetected and the positive result is greater than 2 times the reporting limit, qualify positive and nondetected results as estimated (J) and or nondetected estimated (UJ), respectively.

4.2.6.18 Sample Result Verification Criteria

- a. Verify and record the quantitation of at least one compound per analytical fraction. If no positive results are reported, use the MS/MSD data to confirm proper computation by the laboratory. Validator and laboratory quantitations must agree within 10 percent.

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4.2.6.19 Sample Result Verification Action

- a. Perform a calculation verification of at least one analyte per fraction and include the re-calculation results in the support documentation section of the validation report. See Appendix A for calculation procedure.
- b. If the re-calculation does not agree with the laboratory result within 10%, contact the laboratory to determine whether the reviewer may have used incorrect information or if the laboratory result is incorrect and requires resubmission. A comment on the final outcome is required in the validation report along with the proper calculation verification.

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4.2.6.20 Percent Solids Criteria

- a. Check the percent solids for each sample to identify any samples that contain <30% solids.

4.2.6.21 Percent Solids Action

- a. If any sample contains <30% solids, qualify positive and nondetected results as estimated (J) or nondetected estimated (UJ), respectively, due to the high moisture content of the sample.
- b. If any sample contains <10% solids, qualify positive results as estimated (J); qualify nondetected results as rejected (UR).

4.2.7 **Deliverables Guidance**

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for Data Validation Quality Assurance Officer (DV/QAO) review.

5.0 **CLP ORGANICS BY GC**

5.1 **Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs) (USEPA CLP Statement of Work (SOW) OLM04.3/OLC03.2/SOM01.1)**

5.1.1 **Applicability**

CLP methodology is used to determine the concentration of certain organochlorine pesticides and polychlorinated biphenyls (PCBs) in groundwater, liquid, and solid sample matrices. Specifically, the CLP TCL includes the following substances:

Aldrin	Dieldrin	Methoxychlor
alpha-BHC	Endosulfan I	Toxaphene
Alpha chlordane	Endosulfan II	Aroclor-1016
beta-BHC	Endosulfan sulfate	Aroclor-1221
delta-BHC	Endrin	Aroclor-1232
gamma-BHC (Lindane)	Endrin aldehyde	Aroclor-1242
Gamma Chlordane	Endrin ketone	Aroclor-1248
4,4'-DDD	Heptachlor	Aroclor-1254
4,4'-DDE	Heptachlor epoxide	Aroclor-1260

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4,4'-DDT

CLP methodology for organochlorine pesticides and PCBs is a Gas Chromatographic (GC) procedure in which samples are first extracted and then analyzed by direct injection. The compounds of interest are analyzed via GC/ECD (Electron Capture Detector; an equivalent Halogen-Specific Detector may also be used).

5.1.2 Interferences

Solvents, reagents, glassware, and other sample processing hardware may yield discrete artifacts that cause elevated baselines and lead to potential misinterpretation of chromatograms. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by running method blanks. The use of high purity reagents and solvents ^{TD} 4/27/11 minimize interference problems; purification of solvents by distillation in all-glass systems may be

Interferences co-extracted from the sample will vary considerably and will dictate the nature and extent of clean-up procedures used. Phthalate esters are a common interference to organochlorine pesticide analyses; phenols and organic acids may act as interferents when analyzing for chlorinated herbicides.

5.1.3 General Laboratory Practices

An extraction blank should be prepared with each batch of samples extracted.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analyses should be conducted to determine the effects of sample matrix upon the compounds of interest.

Standard quality assurance practices such as the analyses of field replicates should also be employed.

5.1.4 Sample Preparation

Prior to GC analysis, aqueous samples are extracted at a neutral pH with methylene chloride as a solvent using a separatory funnel or a continuous liquid-liquid extractor. Solid samples are extracted with hexane:acetone (1:1) using sonication procedures.

5.1.5 Data Overview Prior to Validation

Before commencing validation, the reviewer must preview the associated Chain-of-Custody (COC) reports to determine:

- If the appropriate number of samples are present in the data package and if each sample was correctly analyzed for the parameters and methods specified.
- The identity of all associated field quality control blanks and field duplicate pairs.

NOTE: Unless specifically directed by client protocol, never annotate the laboratory data package.

- Prepare working copies of all Form I reports (including those for samples, laboratory method blanks, and MS/MSD analyses) and all laboratory quality control summary forms (including all initial and continuing calibration summary statistics).

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5.1.6 Technical Evaluation Summary

Conduct all data evaluations in accordance with applicable USEPA Regional protocols (when applicable) and/or specific client contract requirements. Reference the applicable documents during the data evaluation process as this S.O.P. is only intended as a general procedure for the data validation tasks.

Evaluate general parameters such as Data Completeness, Overall System Performance, Chromatographic Quality, Detection Limits, and Compound Identification concurrently with the parameters discussed in the following subsections.

5.1.6.1 Holding Times and Sample Preservation Criteria TD 4/27/11

Verify that holding times are evaluated by reviewing the CO the individual sample Form I reports, and the associated laboratory raw data. Calculate holding times for extraction from date of collection to date of extraction. Verify that samples are stored to method requirements. Use the following rules:

- For aqueous samples, use a 7-day maximum holding time until extraction.
- For soil samples, use a 14-day maximum holding time until extraction.
- For sample extracts use a holding time of 40 days from date of extraction to analysis.
- Verify that all samples were stored at $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$ prior to extraction.
- Verify that all extracts were stored at $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

5.1.6.2 Holding Times and Sample Preservation Action

- If holding times are exceeded, qualify positive results in affected samples as estimated (J); qualify nondetects as nondetected estimated (UJ). These results are usually assumed to be biased low unless prolonged storage causes a concentration increase, e.g., for degradation products which are also target analytes.
- If holding times are exceeded by a factor of more than two times the required time, qualify positive results as estimated (J); qualify nondetects as nondetected rejected (UR). These exceedances are considered to be gross holding time exceedances.
- If EPA Regional requirements apply, as in EPA Region III, apply the appropriate bias qualifiers as required; for example, detections and nondetects biased low (L) or (UL), respectively.
- If samples are received above the required temperature, use professional judgment in applying qualifiers. Consider the length of time in storage, the inferred holding temperature, and other factors that could affect the target analyte concentrations.

5.1.6.3 Instrument Performance Check Criteria

At the beginning of the initial calibration sequence, a Resolution Check Mixture is analyzed. A Performance Evaluation Mixture (PEM) is also analyzed at the beginning and end of the initial calibration sequence. After the initial calibration is established the PEM standard is analyzed at the beginning of every other 12-hour analytical period. During the review of the instrument performance check, verify the

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following:

- a. Check that the frequency of both the Resolution Check Mix and the PEM standard satisfy the analytical sequence criteria stated above.
- b. Check that resolution between any two adjacent peaks in the Resolution Check Mix are greater than or equal to 60% on each column.
- c. Check that resolution between any two adjacent peaks in the PEM are greater than or equal to 90% on each column.
- d. Check that the breakdown of 4,4'-DDT and Endrin in each PE ^{TD} 4/27/11 %
- e. Check that the combined breakdown of 4,4'-DDT and Endrin in M is <30.0%

5.1.6.4 Instrument Performance Check Action

- a. If the resolution criterion is not met in either the Resolution Check Mix or the PEM, qualify positive results as estimated (J). Use professional judgment to determine if nondetected data should be qualified as nondetected rejected (UR).
- b. If 4,4'-DDT breakdown exceeds 20%, qualify positive results for 4,4'-DDE and 4,4'-DDD as estimated (J).
- c. If 4,4'-DDT breakdown exceeded 20% and 4,4'-DDT was not detected but 4,4'-DDD and 4,4'-DDE were detected, then qualify positive results for 4,4'-DDD and 4,4'-DDE as presumptively present (NJ) and qualify the nondetected result for 4,4'-DDT as nondetected rejected (UR).
- d. If Endrin breakdown exceeds 20%, qualify positive results for Endrin aldehyde and Endrin Ketone as estimated (J).
- e. If Endrin breakdown exceeded 20% and Endrin was not detected but Endrin aldehyde and Endrin Ketone were detected, then qualify positive results for Endrin aldehyde and Endrin Ketone as presumptively present (NJ) and qualify the nondetected result for Endrin as nondetected rejected (UR).
- f. If the combined breakdown of 4,4'-DDT and Endrin exceed 30.0%, qualify results as described above based upon the degree of individual breakdown.

5.1.6.5 Calibration Criteria

Individual Mixes A and B are analyzed to establish an initial calibration curve on each GC and instrument used for analysis. The Individual Mixes A and B are analyzed at periodic intervals in the analytical sequence as calibration verification standards. During the review of the analytical calibration sequence, verify the following:

- a. Individual Mixes A and B were analyzed at a Low, Medium, and High level on each GC column and instrument.
- b. The %RSD for all single component pesticides are <20.0%
- c. Individual Mixes A and B were analyzed every other 12-hour period.

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- d. For method OLC03.2, the %RSD for delta BHC and alpha BHC are <25.0%
- e. The calibration verification %Ds for all single component pesticides are <25.0%.

5.1.6.6 Calibration Action

- a. If the %RSD of any compound in Individual Mix A or B exceeds 20%, qualify positive results as estimated (J) reported on the column which on noncompliance occurs. If the noncompliance occurs on both analytical columns, qualify nondetects as nondetected estimated (UJ).
- b. For OLC03.2, if the %RSD for delta BHC or alpha BHC exceeds ^{TD}4/27/11 %, qualify positive results as estimated (J) reported on the column which on noncompliance occurs. If the noncompliance occurs on both analytical columns qualify nondetects as nondetected estimated (UJ).
- c. If the %D of any compound in Individual Mix A or B exceeds 20%, qualify positive results as estimated (J) reported on the column which on noncompliance occurs. If the noncompliance occurs on both analytical columns qualify nondetects as nondetected estimated (UJ).

5.1.6.7 Blank Contamination

When using the information given below and in the appropriate USEPA Regional Functional Guidelines, keep in mind that the validation action levels derived are sample specific and must be adjusted for dilution, sample aliquot used for analysis, and sample moisture content (when applicable).

The rules for qualifying data based on the occurrence of blank contamination vary based on regional protocols. The guidelines provided in the appropriate protocol should be followed. Verify the following:

- a. A method or laboratory preparation blank must be analyzed during each 12-hour period.
- b. The method blank should be free of contamination.
- c. Note that unlike volatile fraction analyses, a laboratory method blank does not have to be analyzed after every continuing calibration standard. Be very sure, however, that one pesticide/PCB method blank was extracted for each day that associated samples were extracted (with a maximum of 20 samples per batch).
- d. Instrument blanks must be analyzed at the beginning and end of each 12-hour analytical sequence.

5.1.6.8 Blank Contamination Action

- a. If a target compound is detected in any preparation or instrument blank:
 - 1) Select the maximum concentration of a particular contaminant occurring in the laboratory method blanks. (Do not consider lab blanks run after high concentration samples for purposes of determining carryover as laboratory method blanks!)
 - 2) Establish an action level for qualification of 5X the maximum contaminant concentration.
 - 3) Raise positive results that are less than the established blank action level to the Contract Required Quantitation Limit (CRQL) and qualify them as nondetect (U). In accordance with some

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USEPA Regional protocol, the (B) qualifier may be used instead of (U) when qualifying positive results. In this case, qualify results at the concentration detected instead of the CRQL.

- b. If a target compound was detected in a field quality control blank, carefully evaluate the associated samples to determine the appropriate action. Typically, field quality control blanks are not used to establish blank action levels but professional judgment may be used. When the reviewer decides to use a field quality control blank to qualify associated environmental samples, the guideline above must be followed.

5.1.6.9 Surrogate Criteria

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Evaluate surrogate recoveries by reviewing the laboratory data; Form II reports and the laboratory raw data.

- a. Verify that the recoveries are within the quality control ranges as given on the laboratory data package Form IIs; circle any noncompliances on your working copies of these Forms.
- b. Verify that the decachlorobiphenyl (DCB) and tetrachloro-m-xylene (TCX) retention times found on data package Form VIII are within +/- 0.10 minutes for DCB and 0.05 minutes for TCX. If DCB and TCX retention time criteria are not met, the raw data must be checked for misidentified GC peaks.

5.1.6.10 Surrogate Action

- a. If any surrogate recovery exceeds the upper quality control limit, qualify positive results in that fraction as estimated (J); do not qualify nondetects. A bias qualifier may be used in certain Regions. In accordance with some USEPA Regional protocol, the (K) qualifier may be used instead of (J) when qualifying positive results
- b. If any surrogate recovery is below the lower quality control limit but are >10%, qualify positive and nondetected results in the associated fraction as estimated (J) or nondetected estimated (UJ), respectively. These results are biased low. A bias qualifier may be used in certain Regions. In accordance with some USEPA Regional protocol, the (L,UJ) qualifiers may be used instead of (J, UJ) when qualifying results
- c. If any surrogate recovery is <10% in a given fraction, qualify positive results in that fraction as qualified as estimated (J); qualify nondetects as nondetected rejected (UR). These results are biased very low. The bias qualifiers (L, UL) may be used instead, depending upon the specific USEPA Regional guidance.
- d. If any surrogate retention times have drifted outside of the specified retention time windows, use professional judgment to evaluate the potential impact and usability. Consider the degree of drift and any other factors that are relevant.

5.1.6.11 Matrix Spike/Matrix Spike Duplicates

Verify that matrix spike and matrix spike duplicate recoveries and Relative Percent Differences (RPD) meet quality control limits. Circle outliers on the Form III or equivalent.

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5.1.6.12 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Action

- a. Take no action based on MS/MSD noncompliances alone.
- b. If a matrix spike or matrix spike duplicate recovery is <10%, qualify positive results in the unspiked sample as estimated (J) and qualify nondetects as nondetected rejected (UR).

5.1.6.13 Field Duplicate Precision Criteria

- a. Check samples to determine if field duplicates were included ^{TD} a package
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- b. The Relative Percent Difference (RPD) between field duplicate for the aqueous matrix should be <30%; for soil matrix results, <50% for sample results greater than the reporting limit.

5.1.6.14 Field Duplicate Precision Action

- a. If positive results are greater than the reporting limit, qualify positive results for aqueous or soil media if the RPD exceeds 30% or 50% respectively. Qualification of the sample data is limited to the specific field duplicate pair. Positive results for compounds showing imprecision are qualified as estimated (J). Bias for these results cannot be determined.
- b. If one result is positive and the other is nondetected and the positive result is greater than 2 times the reporting limit, qualify positive and nondetected results as estimated (J) or (UJ), respectively.

5.1.6.15 Sample Result Verification Criteria

- a. Verify and record the quantitation of at least one compound per analytical fraction. If no positive results are reported, use the MS/MSD data to confirm proper computation by the laboratory. Validator and laboratory quantitations must agree within 10 percent.

5.1.6.16 Sample Result Verification Action

- a. Perform a calculation verification of at least one analyte per fraction and include the re-calculation results in the support documentation section of the validation report. See Appendix A for calculation procedure.
- b. If the re-calculation does not agree with the laboratory result within 10%, contact the laboratory to determine whether the reviewer may have used incorrect information or if the laboratory result is incorrect and requires resubmission. A comment on the final outcome is required in the validation report along with the proper calculation verification.

5.1.6.17 Percent Solids Criteria

- a. Check the percent solids for each sample to identify any samples that contain <30% solids.

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5.1.6.18 Percent Solids Action

- a. If any sample contains <30% solids, qualify positive and nondetected results as estimated (J) or nondetected estimated (UJ), respectively, due to the high moisture content of the sample.
- b. If any sample contains <10% solids, qualify positive results as estimated (J); qualify nondetected results as rejected (UR).

5.1.6.19 Target Compound Identification Criteria

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Verify the following:

- a. Check that the retention times of surrogates and target compounds fall within the retention time windows determined from the initial calibration.
- b. Check that reported target compounds were analyzed confirmed on two dissimilar columns.
- c. Check that the %D between positive results is < 25 % for single component compounds.
- d. Compare the chromatographic pattern of positively reported multicomponent compounds (e.g. Aroclors) to standards in order to verify pattern agreement and proper identification.
- e. Check that the lower of the two column positive results are reported.

5.1.6.20 Target Compound Identification Action

- a. If the retention times of any compounds fall outside of the established retention time windows, use professional judgment to determine data usability.
- b. If the %D between columns for positive results exceeds 25% but is <100%, qualify the positive result as estimated (J).
- c. If the %D between columns for positive results is >100%, then the positive result may be rejected (R). However, professional judgment should be used to evaluate the chromatogram prior to rejecting the positive result. It should be noted that this action is limited to single component compounds.
- d. If the %D between columns for multicomponent compounds is >25% but <500%, qualify the positive result as estimated (J). If the %D is >500%, use professional judgment to determine if rejection (R) is necessary.

5.1.7 Deliverables Guidance

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for Data Validation Quality Assurance Officer (DV/QAO) review.

6.0 REFERENCES

Department of Defense (DoD) Environmental Data Quality Workgroup, 2006. Quality Systems Manual

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U.S. EPA Region I, 2004. Part III Pesticide/PCB Data Validation Functional Guidelines, February.

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APPENDIX A SAMPLE CALCULATIONS

Exhibit D Low/Medium Volatiles -- Section 11
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11.2.1.2 Water

EQ. 7 Water Concentration Calculation

$$\text{Concentration } (\mu\text{g/L}) = \frac{(A_x) (I_s) (DF)}{(A_{is}) (\overline{RRF}) (V_o)}$$

Where,

A_x = Area of the characteristic ion (EICP) for the compound to be measured. The primary quantitation ions for the target compounds, internal standards, and DMCs are listed in Table 2.

A_{is} = Area of the characteristic ion (EICP) for the internal standard. The target compounds are listed with their associated internal standards in Table 3.

I_s = Amount of internal standard added, in ng.

\overline{RRF} = Mean Relative Response Factor from the initial calibration.

V_o = Total volume of water purged, in mL.

DF = Dilution Factor. The DF for analysis of water samples for volatiles by this method is defined as the ratio of the number of mL of water purged (i.e., V_o above) to the number of mL of the original water sample used for purging. For example, if 2.0 mL of sample is diluted to 5.0 mL with reagent water and purged, $DF = 5.0 \text{ mL} / 2.0 \text{ mL} = 2.5$. If no dilution is performed, $DF = 1.0$.

11.2.1.3 Low-Level Soil/Sediment

EQ. 8 Low-Level Soil/Sediment Concentration Calculation

$$\text{Concentration } (\mu\text{g/Kg}) \text{ (dry weight basis)} = \frac{(A_x) (I_s) (DF)}{(A_{is}) (\overline{RRF}) (W_s) (D)}$$

Where,

A_x , I_s , A_{is} , and DF are as given for water, Equation 7.

\overline{RRF} = Mean Relative Response Factor from the heated purge of the initial calibration.

$$D = \frac{100 - \% \text{Moisture}}{100}$$

W_s = Weight of sample added to the purge tube, in g.

11.2.1.4 Medium-Level Soil/Sediment

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EQ. 9 Medium-Level Soil/Sediment Concentration Calculation

$$\text{Concentration } \mu\text{g/Kg (dry weight basis)} = \frac{(A_x) (I_s) (AV_t) (1000) (DF)}{(A_{is}) (\overline{RRF}) (V_a) (W_s) (D)}$$

Where,

A_x , I_s , A_{is} are as given for water, Equation 7.

\overline{RRF} = Mean Relative Response Factor from the **ambient** temperature purge of the initial calibration.

AV_t = Adjusted total volume of the methanol extract plus soil water in milliliters (mL) determined by:

$$AV_t = V_t + \{W_s - [W_s(D)]\}$$

Where V_t = total volume of methanol extract in milliliters (mL). This volume is typically 10 mL, even though only 1.0 mL is transferred to the vial in Section 10.1.5.5. The quantity derived from $\{W_s - [W_s(D)]\}$ is the soil water volume and is expressed in mL.

V_a = Volume of the aliquot of the sample methanol extract (i.e., sample extract not including the methanol added to equal 100 μL), in microliters (μL) added to reagent water for purging.

W_s = Weight of soil/sediment extracted, in g.

$$D = \frac{100 - \% \text{Moisture}}{100}$$

DF = Dilution Factor. The DF for analysis of soil/sediment samples for volatiles by the medium-level method is defined as:

$$\frac{\mu\text{L most conc. extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most conc. extract used to make dilution}}$$

11.2.1.5 For water, low-level and medium-level soil/sediment samples, xylenes are to be reported as "m,p-xylenes" and "o-xylene". Because m- and p-xylene isomers coelute, special attention must be given to the quantitation of the xylenes. In quantitating sample concentrations, be sure to use the correct corresponding Relative Response Factor (RRF) values.

NOTE: The area of each peak (i.e., the peaks for o-xylene and m,p-xylene) must appear on the complete quantitation report.

11.2.1.6 The stereoisomers, trans-1,2-dichloroethene, and cis-1,2-dichloroethene are to be reported separately.

11.2.1.7 Secondary ion quantitation is allowed **only** when there are sample matrix interferences with the primary ion. If secondary ion quantitation is performed, document the reasons in the SDG Narrative. A secondary ion cannot be used unless an RRF is calculated using the secondary ion.

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compound coelution, baseline noise, or matrix interferences. In these circumstances, the Contractor must perform a manual quantitation. Manual quantitations are performed by integrating the area of the quantitation ion of the compound. This integration shall only include the area attributable to the specific TCL compound. The area integrated shall not include baseline background noise. The area integrated shall not extend past the point where the sides of the peak intersect with the baseline noise. Manual integration is not to be used solely to meet Quality Control (QC) criteria, nor is it to be used as a substitute for corrective action on the chromatographic system. Any instance of manual integration must be documented in the SDG Narrative.

11.2.1.3 In all instances where the data system report has been edited or where manual integration or quantitation has been performed, the GC/MS Operator must identify such edits or manual procedures by initialing and dating the changes made to the report, and shall include the integration scan range. The GC/MS Operator shall also mark each integrated area with the letter "M" on the quantitation report. In addition, a hardcopy printout of the EICP of the quantitation ion displaying the manual integration shall be included in the raw data. This applies to all compounds listed in Exhibit C (Semivolatiles), internal standards, and DMCs.

11.2.1.4 The requirements listed in Sections 11.2.1.1 - 11.2.1.3 apply to all standards, samples, and blanks.

11.2.1.5 The Mean Relative Response Factor (\overline{RRF}) from the initial calibration is used to calculate the concentration in the sample. Secondary ion quantitation is allowed ONLY when there are sample interferences with the primary ion. If secondary ion quantitation is performed, document the reason in the SDG Narrative. The area of a secondary ion cannot be used for the area of a primary ion unless a \overline{RRF} is calculated using the secondary ion.

11.2.1.6 Calculate the concentration in the sample using the \overline{RRF} and Equations 5 and 6.

11.2.1.6.1 Water

EQ. 5 Concentration of Water Sample

$$\text{Concentration } \mu\text{g/L} = \frac{(A_x) (I_s) (V_t) (DF) (GPC)}{(A_{is}) (\overline{RRF}) (V_o) (V_i)}$$

Where,

A_x = Area of the characteristic ion for the compound to be measured.

A_{is} = Area of the characteristic ion for the internal standard.

I_s = Amount of internal standard injected in ng.

V_o = Volume of water extracted in mL.

V_i = Volume of extract injected in μL .

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V_t = Volume of the concentrated extract in μL (If GPC Cleanup is performed, $V_t = V_{out}$).

\overline{RRF} = Mean Relative Response Factor determined from the initial calibration standard.

$GPC = \frac{V_{in}}{V_{out}}$ = GPC factor. (If no GPC is performed, $GPC = 1$).

V_{in} = Volume of extract loaded onto GPC column.

V_{out} = Volume of extract collected after GPC cleanup.

DF = Dilution Factor. The DF for analysis of water samples for semivolatiles by this method is defined as follows:

$$DF = \frac{\mu\text{L most conc. extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most conc. extract used to make dilution}}$$

If no dilution is performed, $DF = 1.0$.

11.2.1.6.2 Soil/Sediment

EQ. 6 Concentration of Soil/Sediment Sample

$$\text{Concentration } \mu\text{g/Kg (Dry weight basis)} = \frac{(A_x) (I_s) (V_t) (DF) (GPC)}{(A_{is}) (\overline{RRF}) (V_i) (W_s) (D)}$$

Where,

A_x , I_s , A_{is} , V_{in} , and V_{out} are as given for water, above.

V_t = Volume of the concentrated extract in μL
(If no GPC Cleanup is performed, then $V_t = 1000 \mu\text{L}$.
If GPC Cleanup is performed, then $V_t = V_{out}$).

V_i = Volume of the extract injected in μL .

$$D = \frac{100 - \% \text{ Moisture}}{100}$$

W_s = Weight of sample extracted in g.

$GPC = \frac{V_{in}}{V_{out}}$ = GPC Factor

\overline{RRF} = Mean Relative Response Factor determined from the initial calibration standard.

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DF = Dilution Factor. The DF for analysis of soil/sediment samples for semivolatiles by this method is defined as follows:

$$DF = \frac{\mu\text{L most conc. extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most conc. extract used to make dilution}}$$

If no dilution is performed, DF = 1.0.

A GPC factor of 2.0 is used to account for the amount of extract that is not recovered from the mandatory use of GPC cleanup. Concentrating the extract collected after GPC to 0.5 mL maintains the sensitivity of the soil/sediment method.

11.2.2 Non-Target Compound

An estimated concentration for non-target compounds tentatively identified shall be quantitated by the internal standard method. For quantitation, the nearest internal standard free of interferences shall be used. The equations for calculating concentration are the same as Equations 5 and 6. Total area counts (or peak heights) from the total ion chromatograms are to be used for both the compounds to be measured and the internal standard. An RRF of 1 is to be assumed. The resulting concentration shall be qualified as "J" (estimated, due to lack of a compound specific response factor), and "N" (presumptive evidence of presence), indicating the quantitative and qualitative uncertainties associated with this non-target component. An estimated concentration should be calculated for all TICs as well as those identified as unknowns.

11.2.3 CRQL Calculations

11.2.3.1 Water Samples

EQ. 7 Aqueous Adjusted CRQL

$$\text{Adjusted CRQL} = \text{Contract CRQL} \times \frac{(V_x)(V_t)(DF)}{(V_o)(V_c)}$$

Where,

V_t , DF, and V_o are as given in Equation 5.

V_x = Contract sample volume (1000 mL).

V_c = Contract concentrated extract volume (1000 μ L if GPC is not performed. If GPC was performed, then $V_c = V_{out}$).

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- 11.2.1.4 The Contractor must quantitate Toxaphene based on the Mean Calibration Factors (CFs) from the most recent initial calibration.
- 11.2.1.5 The chromatograms of all samples [including Laboratory Control Samples (LCSs), Matrix Spikes and Matrix Spike Duplicates (MS/MSDs)], standards, and required blanks must be reviewed by a qualified pesticide analyst before they are reported.
- 11.2.1.6 Calculate the sample concentration and on-column concentration of the single component pesticides and surrogates by using the following equations.
- 11.2.1.6.1 Water
- 11.2.1.6.1.1 EQ. 14 Concentration Calculation of Target Compounds in Water Samples

$$\text{Concentration } \mu\text{g/L} = \frac{(A_x) (V_t) (DF) (GPC)}{(\overline{CF}) (V_o) (V_i)}$$

Where,

A_x = Response (peak area or height) of the compound to be measured.

\overline{CF} = Mean Calibration Factor from the initial calibration (area/ng).

V_{in} = Volume of extract loaded onto GPC column.

V_{out} = Volume of extract collected after GPC cleanup.

V_t = Volume of concentrated extract (μL). (If GPC is not performed, then $V_t = 10,000 \mu\text{L}$. If GPC is performed, then $V_t = V_{out}$.)

V_i = Volume of extract injected (μL). (If a single injection is made onto two columns, use $\frac{1}{2}$ the volume in the syringe as the volume injected onto each column).

$GPC = \frac{V_{in}}{V_{out}}$ = Gel Permeation Chromatography factor. (If no GPC is performed, $GPC = 1.0$)

V_o = Volume of water extracted (mL). (NOTE: for instrument blanks and sulfur cleanup blanks, assume a 1,000 mL volume).

DF = Dilution Factor. The DF is defined as follows:

$$\frac{\mu\text{L most concentrated extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most concentrated extract used to make dilution}}$$

If no dilution is performed, $DF = 1.0$.

The \overline{CF} s used in Equations 14 - 17 are those from the most recent initial calibration. If the CFs used to determine the linearity of the initial calibration were based on peak area, then the concentration of the analyte in the sample

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must be based on peak area. Similarly, if peak height was used to determine linearity, use peak height to determine the concentration in the sample.

11.2.1.6.1.2 EQ. 15 On-Column Concentration of Water Sample Extract

$$\text{On-Column Concentration (ng/}\mu\text{L)} = \frac{(A_x)}{(\overline{CF}) (V_i)}$$

Where,

A_x = Same as EQ. 14.

\overline{CF} = Same as EQ. 14.

V_i = Volume of extract injected (μL). (If a single injection is made onto two columns, use $\frac{1}{2}$ the volume in the syringe as the volume injected onto each column).

11.2.1.6.2 Soil/Sediment

11.2.1.6.2.1 EQ. 16 Concentration of Target Compounds in Soil/Sediment Samples

$$\text{Concentration } \mu\text{g/Kg (Dry weight basis)} = \frac{(A_x) (V_t) (DF) (GPC)}{(\overline{CF}) (V_i) (W_s) (D)}$$

Where,

A_x = Same as EQ. 14.

\overline{CF} = Same as EQ. 14.

V_t = Same as EQ. 14.

V_i = Volume of extract injected (μL). (If a single injection is made onto two columns, use $\frac{1}{2}$ the volume in the syringe as the volume injected onto each column).

W_s = Weight of sample extracted (g).

DF = Same as EQ. 14.

D = % dry weight or $\frac{100 - \% \text{Moisture}}{100}$

GPC = Same as EQ. 14.

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11.2.1.6.2.2 EQ. 17 On-Column Concentration of Soil Sample Extract

$$\text{On-Column Concentration (ng/}\mu\text{L)} = \frac{(A_x)}{(\overline{CF})(V_i)}$$

Where,

A_x = Same as EQ. 14.

\overline{CF} = Same as EQ. 14.

V_i = Volume of extract injected (μL). (If a single injection is made onto two columns, use $\frac{1}{2}$ the volume in the syringe as the volume injected onto each column).

11.2.1.7 The lower of the two concentrations calculated for each single component pesticide is reported on Form I. In addition, the concentrations calculated for both the GC columns are reported on Form X, along with a Percent Difference (%Difference) comparing the two concentrations. The Percent Difference is calculated according to Equation 18.

EQ. 18 Percent Difference Between Concentrations on Both GC Columns

$$\%D = \frac{\text{Conc}_H - \text{Conc}_L}{\text{Conc}_L} \times 100$$

Where,

Conc_H = The higher of the two concentrations for the target compound in question.

Conc_L = The lower of the two concentrations for the target compound in question.

NOTE: Using this equation will result in Percent Difference values that are always positive.

11.2.1.8 The quantitation of Toxaphene must be accomplished by comparing the heights or the areas of each of the three or four major peaks of in the sample with the CF for the same peaks established during the initial calibration sequence. The concentration of Toxaphene is calculated by using Equations 14 and 16, where A_x is the area for each of the major peaks. The concentration of each peak is determined and then a mean concentration for the three or four major peaks is determined on each column.

11.2.1.9 The reporting requirement for Toxaphene is similar to that for the single component analytes, except that the lower mean concentration (from three or four peaks) is reported on Form I, and the two mean concentrations reported on Form X. The two mean concentrations are compared by calculating the Percent Difference using Equation 18.

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- 11.1.2.9 If the identification of the analyte cannot be confirmed by any of the GC/MS procedures above, and the concentration calculated from the GC/ECD analysis is greater than or equal to the concentration of the reference standard analyzed by GC/MS, then report the analyte as undetected, adjust the sample quantitation limit (the value associated with the "U" qualifier) to a sample concentration equivalent to the concentration of the GC/MS reference standard, and qualify the results on Form I with one of the laboratory-defined qualifiers ("X", "Y", or "Z"). In this instance, define the qualifier explicitly in the Sample Delivery Group (SDG) Narrative, and describe the steps taken to confirm the analyte in the SDG Narrative.
- 11.1.2.10 For GC/MS confirmation of Aroclors, spectra of three characteristic peaks are required for both the sample component and the reference standard.
- 11.1.2.11 The purpose of the GC/MS analysis for the Aroclors is to confirm the presence of chlorinated biphenyls in Aroclors. The GC/MS analytical results for the Aroclors shall not be used for quantitation and the GC/MS results shall not be reported on Form I and Form X. The exception noted in Section 11.1.2.9 applies only to analytes that cannot be confirmed above the reference standard concentration.

11.2 Calculations

11.2.1 Aroclor Concentrations

11.2.1.1 Water

11.2.1.1.1 EQ. 7 Concentration Calculation for Water Samples

$$\text{Concentration } \mu\text{g/L} = \frac{(A_x) (V_t) (DF) (GPC)}{(\overline{CF}) (V_o) (V_i)}$$

Where,

A_x = Area or height of the peak for the compound to be measured.

\overline{CF} = Mean Calibration Factor from the specific five-point calibration (area/ng).

V_o = Volume of water extracted in mL (Note: for instrument and sulfur blanks assume a volume of 1000 mL).

V_i = Volume of extract injected in μL . (If a single injection is made onto two columns, use one half the volume in the syringe as the volume injected onto each column).

V_t = Volume of the concentrated extract in μL . (If GPC is not performed, then $V_t = 10000 \mu\text{L}$. If GPC is performed, then $V_t = V_{out}$).

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DF = Dilution Factor. The DF for analysis of water samples by this method is defined as follows:

$$\frac{\mu\text{L most concentrated extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most concentrated extract used to make dilution}}$$

If no dilution is performed, DF = 1.0.

$$\text{GPC} = \frac{V_{\text{in}}}{V_{\text{out}}} = \text{GPC factor. (If no GPC is performed, GPC} = 1.0).$$

V_{in} = Volume of extract loaded onto GPC column.

V_{out} = Volume of extract collected after GPC cleanup.

11.2.1.1.2 EQ. 8 On-Column Concentration of Water Sample Extract

$$\text{On-Column Concentration (ng}/\mu\text{L)} = \frac{(A_x)}{(\overline{\text{CF}}) (V_i)}$$

Where,

A_x = Same as EQ. 7.

$\overline{\text{CF}}$ = Same as EQ. 7.

V_i = Volume of extract injected (μL). (If a single injection is made onto two columns, use $\frac{1}{2}$ the volume in the syringe as the volume injected onto each column).

11.2.1.2 Soil/Sediment

11.2.1.2.1 EQ. 9 Concentration Calculation for Soil Samples

$$\text{Concentration } \mu\text{g}/\text{Kg (Dry weight basis)} = \frac{(A_x) (V_t) (DF) (GPC)}{(\overline{\text{CF}}) (V_i) (W_s) (D)}$$

Where,

A_x , V_t , $\overline{\text{CF}}$, and GPC are as given for water in EQ 7.

V_i = Volume of extract injected in μL . (If a single injection is made onto two columns, use one half the volume in the syringe as the volume injected onto each column.)

SOM01.1 (5/2005)

D-48/ARO

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$$D = \frac{100 - \% \text{Moisture}}{100}$$

W_s = Weight of sample extracted in g.

DF = Dilution Factor. The DF for analysis of soil/sediment samples by this method is defined as follows:

$$\frac{\mu\text{L most concentrated extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most concentrated extract used to make dilution}}$$

If no dilution is performed, DF = 1.0.

11.2.1.2.2 EQ. 10 On-Column Concentration of Soil Sample Extract

$$\text{On-Column Concentration (ng/\mu L)} = \frac{(A_x)}{(\overline{CF})(V_1)}$$

Where,

A_x = Same as EQ. 7.

\overline{CF} = Same as EQ. 7.

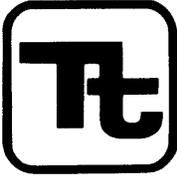
V_1 = Volume of extract injected (μL). (If a single injection is made onto two columns, use $\frac{1}{2}$ the volume in the syringe as the volume injected onto each column).

11.2.2 Target Compounds

The quantitation of Aroclors must be accomplished by comparing the heights or the areas of each of a minimum of 3 major peaks of the Aroclor in the sample with the \overline{CF} for the same peaks established during the specific five-point calibration. The concentration of multi-component analytes is calculated by using Equations 7 and 9, where A_x is the area for each of the major peaks of the Aroclor. The concentration of each peak is determined and then a mean concentration for a minimum of 3 major peaks is determined on each column.

11.2.2.1 Note that the \overline{CF} s used for the quantitation of Aroclors are the \overline{CF} s from the concentration of the specific five-point calibration.

11.2.2.2 The lower mean concentration (from a minimum of 3 peaks) is reported on Form I, and the two mean concentrations reported on Form X. The two mean concentrations are compared by calculating the Percent Difference (%Difference) using Equation 11.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability Tetra Tech NUS, Inc.	
Prepared Chemistry and Toxicology Department	

Subject
DATA VALIDATION – CLP INORGANICS FOR SOLID AND AQUEOUS MATRICES

Approved
Tom Johnston *T.E. Johnston*

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1.0 PURPOSE

This SOP governs the validation of data generated by inorganics CLP STATEMENT OF WORK (SOW) ILM05.3. As additional inorganic quantification methods are developed, the corresponding validation protocols may be added to this SOP.

2.0 APPLICABILITY

The applicability of these validation criteria is described in the appropriate sections below.

3.0 PERSONNEL QUALIFICATIONS

The minimum qualifications of persons implementing this SOP are as follow:

- Education – Minimum of a bachelor’s degree in chemistry or related physical/life science.
- Experience requirements include either operational experience with the analytical method or method data review training conducted under the direction of an experienced reviewer and performed on the subject matter data package. A record of the training will not be documented and kept on file but the data validation report produced under training will serve as the record.

4.0 INORGANICS (CLP STATEMENT OF WORK (SOW) ILM05.3)

4.1 Applicability

This method is applicable to a large number of matrices including EP extracts, TCLP extracts, industrial wastes, soils, groundwater, aqueous samples, sludges, sediments, and other solid wastes. All matrices require digestion prior to analysis.

The following analytes are commonly determined by this method:

Inductively Coupled Plasma Emission Spectroscopy (ICP)

Aluminum	Cobalt	Potassium
Barium	Copper	Silver
Beryllium	Iron	Sodium
Cadmium	Magnesium	Vanadium
Calcium	Manganese	Zinc
Chromium	Nickel	

Graphite Furnace Atomic Absorption Spectroscopy (GFAA)

Antimony	Selenium
Arsenic	Thallium

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Cold Vapor Methodology

Mercury

Automated Colorimetric Technique

Cyanide

4.2 Interferences

Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All of these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks. Specific selection of reagents and purification of solvents by distillation in all-glass systems may be necessary.

4.3 General Laboratory Practices

The data reviewer must initially verify that a method blank consisting of deionized water was analyzed immediately following each daily calibration, and also after the analysis of every high concentration sample.

Matrix Spike/Matrix Spike Duplicate (MS/MSD) analyses should be conducted to determine the effects of sample matrix upon the compounds of interest.

4.4 Sample Preparation

The data reviewer must initially verify that samples being prepared for ICP, GFAA, and Cold Vapor methodologies are prepared using acid extraction. Samples being prepared for automatic colorimetric technique for Cyanide analysis are prepared using distillation. Additionally the data reviewer must verify that prior to analysis, MS and LCS aqueous and soil samples are spiked with internal standard. The samples are filtered and the extract is ready for CLP analysis.

4.5 Data Overview Prior to Validation

The data reviewer must initially verify that all CLP Forms are present and complete (i.e., Forms 1 through 14 must be provided). Areas of special attention when accounting for required CLP Forms will include:

- a. Verify at least one Initial and Continuing Calibration Verification (ICV/CCV) Percent Recovery (%R) calculation as noted on the Form 2A.
- b. When reviewing Form 2B, verify that all atomic absorption (GFAA) analytes are present in the CRDL standard at concentrations at the CRDL. Verify that all ICP analytes (with the exceptions of Al, Ba, Ca, Fe, Mg, Na and K) are present in the CRDL standard at concentrations of 2X CRDL.
- c. Verify that a matrix-specific laboratory generated preparation blank has been analyzed for each respective matrix as noted on the Form 3 (note that filtered and unfiltered aqueous matrices are to be treated as distinctly different matrices).
- d. Verify that all ICP analytes are present in both ICSA and ICSAB solutions. (Note that SOW 3/90 ILM03.0 does not require that antimony, sodium, and potassium be present in these solutions).

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Also verify from the raw data that the laboratory reported all analytes present in solution A to the nearest whole number. It is not uncommon for laboratories to incorrectly report "zeros" or simply leave blank the appropriate solution A columns. Furthermore, %Rs for solution AB are to be reported to one decimal place on the Form 4.

- e. Check that one matrix spike was analyzed for each particular matrix per analytical batch. Laboratories typically will not include an aqueous matrix for waters if the only aqueous samples contained in the SDG are field quality control blanks (i.e., equipment rinsate blanks and/or field blanks). This is generally accepted without data validation letter text comment. Additionally, the data reviewer may want to verify spiking levels as noted on pg. E-20 of ILM05.3 Inorganic SOW.
- f. Verify that laboratory duplicate analyses were performed for each matrix. **NOTE:** Field quality control blanks are never to be designated for quality control analyses.
- g. Check that one Laboratory Control Sample (LCS) was analyzed for each batch of samples per matrix within an SDG. **NOTE:** An aqueous LCS is not required for mercury and cyanide analysis.
- h. The Method of Standard Additions (MSA) Form 8 may or may not be present as dictated by Post Digestion Spike (PDS) %Rs. See Section 3.1.3.11 for further details.
- i. Verify that at least one ICP serial dilution analysis was performed for each matrix within an SDG. **NOTE:** Typically one serial dilution will serve to monitor a given set of samples within an SDG. However, special contractual requirements may necessitate one serial dilution analysis per sample. Ascertain atypical serial dilution frequency requirements through the project manager.
- j. Verify that the Form 11 ICP Interelement Correction Factors (Annually) is present.
- k. Verify that all ICP analytical results fall within the ICP Quarterly Linear Ranges provided on the Form 12. Verify that no GFAA analytical results exceed the highest standard used in the associated GFAA calibration.
- l. Verify that the Form 13 Preparation Log accounts for aqueous/soil ICP, AA, mercury, and cyanide digestions/distillations as applicable.
- m. Examine the Form 14s to verify that one and only one "X" flag has been used to signify each reported field sample result or quality control sample result. Laboratories are often careless when entering the "X" flag. An incorrectly entered "X" flag can lead to reporting errors for the sample and its associated QC. The validator must verify reported results in instances of discrepancies, amend appropriate forms, and mention in letter text.

Actions - Notify the appropriate laboratory contact of required resubmittals when discrepancies are noted on the forms discussed above.

4.6 Technical Evaluation Summary

All data evaluations must be conducted in accordance with current and applicable USEPA Regional protocols and/or specific client contractual requirements and obligations. The applicable documents must be referenced to during the data evaluation process as this Standard Operating Procedure (SOP) is intended as proprietary in-house guidance for general inorganic validation practices only.

Evaluate general parameters such as Data Completeness, Overall System Performance, and Detection Limits concurrently with the parameters discussed in the following subsections.

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4.6.1 Holding Times and Sample Preservation Criteria

Holding times are calculated from date of sample collection to date of sample analysis. The date of sample collection must be obtained from the Chain-of-Custody (COC) form. The date of sample analysis is best retrieved from the raw data but may also be obtained from the Form 14.

Sample preservation and holding time requirements are as follows:

- a. Metals - 6 months; pH <2
- b. Mercury - 28 days; pH <2
- c. Cyanide - 14 days; pH >12

Preservation requirements as noted above are applicable to aqueous samples only; solid samples do not receive preservative, but require maintenance at 4°C.(2°C) during shipment and storage.

4.6.2 Holding Time and Sample Preservation Action

- a. If holding times are exceeded, qualify positive results in affected samples as estimated (J); nondetects (UJ). These results are biased low.
- b. If holding times are exceeded by a factor of more than two times the required time, qualify positive results as estimated (J); qualify nondetects as nondetected rejected (UR). These exceedances are considered to be gross holding time exceedances.
- c. If EPA Regional requirements apply, as in EPA Region III, apply the appropriate bias qualifiers as required; for example, positive results and nondetects as biased low (L) or (UL), respectively.
- d. If samples are received above the required temperature, use professional judgment to qualify the results. Consider the length of time outside the prescribed storage temperature range and other relevant factors.

4.6.3 Initial and Continuing Calibration Requirements Criteria

Verify the following:

- a. **ICP analyses** - must employ a blank and at least one standard. Review initial and continuing calibration Form 2As and associated new data. The initial and continuing calibration %R quality control limits are 90-110%.
- b. **GFAA analyses** - must employ a blank and at least three standards. One of the standards must be at the CRDL. Additionally, the calibration correlation coefficient (r) must be checked for linearity for each GFAA analysis performed (i.e., r = 0.995 or greater). The initial and continuing calibration %R quality control limits are 90-110%.
- c. **Mercury analyses** - must employ a blank and at least four standards (r = 0.995 or greater). The initial and continuing calibration %R quality control limits are 80-120%.

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- d. **Cyanide analyses** - must employ a blank and at least three standards ($r = 0.995$ or greater). **NOTE:** The midpoint standard for cyanide analyses must be distilled; verify this via distillation logs. The initial and continuing calibration %R quality control limits are 85-115%.

4.6.4 Calibration Action

- a. If ICV/CCV %Rs are low, qualify all affected positive results as estimated (J); qualify nondetects as estimated (UJ). In accordance with some USEPA Regional protocol, the (L) and (UL) qualifiers may be used when qualifying results. Bias for these results is low.
- b. If ICV/CCV %Rs are high, qualify all affected positive results as estimated (J); nondetects are not affected. In accordance with some USEPA Regional protocol, the (K) qualifier may be used when qualifying results. Bias for these results is high.
- c. Gross exceedance, as defined by applicable data validation protocol, may require rejection (R) of results.

NOTE: Qualify results of only those samples associated with the noncompliant ICB or CCV (generally, those samples immediately preceding or following the noncompliant standard until the nearest in-control standard).

4.6.5 CRDL Standard Analysis Criteria

Review CRDL Standard Form 2Bs and associated new data. The CRDL Standard analysis %R quality control limits are generally 80-120% for all metals.

4.6.6 CRDL Standard Analysis Action

- a. Generally there is no qualification of data for CRDL %Rs. A comment is noted in the validation letter.
- b. In accordance with some EPA Regional protocol, if CRDL %Rs are high, positive results $< 2X$ CRDL (Region III) or $< 3X$ CRDL (Region I) are qualified as biased high (K) or (J), respectively. Note that when using EPA Region I validation guidelines, nondetects will receive qualification based upon high CRDL Standard analysis recovery.
- c. In accordance with some EPA Regional protocol, if CRDL %Rs are low, positive results $< 2X$ CRDL (Region III) or $< 3X$ CRDL (Region I) are qualified as biased low (L) or (J), respectively. Nondetected results are qualified as biased low (UL) or (UJ), respectively.

NOTE: The data reviewer need not specify affected samples; common practice is to apply data qualifications "across-the-board" based upon LOE time constraints.

4.6.7 Blank Contamination Criteria

Verify that a preparation blank was analyzed for each matrix and for each batch of 20 samples or each sample batch digested, whichever is more frequent. Continuing Calibration Blanks (CCBs) must be run at a frequency of 10% or every 2 hours whichever is more frequent.

The data reviewer will select the maximum contaminant level for each analyte in a particular matrix from which shall be calculated an "action level." The action level shall be established as 5X the maximum

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contaminant level but must be adjusted for dilution factor, moisture content, and sample weight prior to application.

ICB/CCB contamination shall be applied to all affected samples within an SDG. Preparation blank contamination shall be applied to samples of the same matrix only. Professional judgment must be employed when discerning the validity of a concentration present in a field quality control blank. In many instances, contamination present in these blanks can be attributable to "dirty" laboratory practice and not actual field contaminant conditions.

Negative concentrations detected in the laboratory method blanks are indicative of instrumental problems and base-line drifting. Generally, any negative concentration > IDL shall warrant review of the associated sample data regardless of matrix. Action levels shall not be established for negative concentration levels.

4.6.8 Blank Contamination Action

- a. Qualify as nondetected (U) any positive result within the action level. In accordance with some USEPA Regional protocol, the (B) qualifier may be used instead of (U) when qualifying positive results.
- b. In accordance with some USEPA Regional protocol results are qualified based on negative blank results. Region III requires if any negative blank concentrations are > CRDL then all samples < 5X CRDL are qualified as biased low (L) and nondetects are qualified (UL). Region I requires if any negative blank results are > 2X IDL the nondetected results are qualified as estimated (UJ) and positive results < CRDL are qualified (J).

4.6.9 ICP Interference Check Criteria

Sample Form 4 and associated raw data. Verify that all recoveries for the ICP ICS solution fall within the 80-120% quality control window established for the ICS AB solution.

Next, review concentrations of the four common interfering analytes (aluminum, calcium, iron, and magnesium) in the environmental samples. Any aforementioned interferant present in the environmental samples at concentrations which exceed 50% (Region III; order of magnitude) of those present in the ICS solution for that same analyte will require calculation of estimated elemental interference stemming from high interfering analyte concentration. If the previous condition is met; review the ICP/ICS Form 4 and note any analytes present in the ICS solution A at levels which exceed the IDL and which are not present in the ICS True solution A. Positive results in the ICS solution A indicate potentially elevated results for this analyte in the affected sample while negative results in the ICS solution A indicate potentially suppressed results for this analyte in the affected sample.

Next, an estimated elemental interference must be calculated for each analyte > IDL present in the ICS solution A which is not present in the ICS True solution A. The following equation shall be employed:

$$\text{Estimated elemental intf.} = \frac{[\text{Conc. affected analyte in ICS Soln A}] \times [\text{Interferent}] [\text{Conc. in Sample}]}{\text{Interferent Conc. in ICS Soln A}}$$

It is advisable, although not necessary, to routinely choose the lowest concentration for the interferant level in the ICS so as to calculate the highest estimated interference possible. This method lends itself to a more conservative overall data quality review.

Estimated interferences for each affected analyte > IDL in the ICSA solution must now be compared to the reported environmental sample result for that particular analyte.

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4.6.10 ICP Interference Check Action

- a. For ICS %Rs <80%, qualify as estimated (J) positive results and (UJ) nondetects in affected samples. In accordance with some EPA Regional protocol, if ICS %Rs are low, positive results are qualified as biased low (L) and nondetects (UL).
- b. For ICS %Rs >120%, qualify as estimated (J) positive results in affected samples; nondetects are unaffected by high ICS solution AB recovery. In accordance with some EPA Regional protocol, if ICS %Rs are high, positive results are qualified as biased high (K).

NOTE: Affected samples include all samples analyzed between the initial and final solutions (or within the eight hour working shift, whichever occurs more frequently) which contain Al, Ca, Fe, or Mg at levels >50% of the respective concentration of Al, Ca, Fe, or Mg in the ICS True Solution A.

- c. For estimated interferences <10% of the reported sample concentration for a particular affected analyte, take no action; interference is considered negligible.
- d. For estimated interferences >10% of the reported sample concentration for a particular affected analyte, qualify (J) positive result and/or (UJ) nondetect for affected analyte in affected sample.

(NOTE: Calculation of an estimated positive (potentially elevated) interference will have no effect on a reported nondetect; thus, no action is necessary).

4.6.11 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Criteria

Review Spike Sample Recovery Form 5A and associated raw data. Verify that at least one matrix spike was performed for each matrix for a given set of samples within an SDG. **NOTE:** Filtered and unfiltered samples are to be treated as distinctly different sample matrices and qualified accordingly. Refer to ILM03.0, 3/90 Inorganic SOW, Table 3, "SPIKING LEVELS FOR SPIKING SAMPLE ANALYSIS," page 20, Section E, for proper analyte spiking concentrations and requirements. Any deviations from the SOW shall be noted and require laboratory contact for correction.

Aqueous and soil Matrix Spike (MS) / Matrix Spike Duplicate (MSD) recoveries must be within the 75-125% quality control window in instances where the initial sample result is <4X amount spiked. If the initial sample result is >4X the amount spiked and the MS %R is noncompliant; no actions shall be taken.

4.6.12 Matrix Spike/Matrix Spike Duplicate (MS/MSD) Action

- a. For MS / MSD %Rs <30%, qualify as estimated (J) positive results and reject (R) nondetects in affected samples. In accordance with some EPA Regional protocol, if MS/MSD %Rs are low, positive results are qualified as biased low (L).
- b. For MS / MSD %Rs <75% but >30%, qualify as estimated (J) positive results and (UJ) nondetects in affected samples. In accordance with some EPA Regional protocol, if MS/MSD %Rs are low, positive results are qualified as biased low (L) and nondetects as (UL).
- c. For MS %Rs >125%, qualify as estimated (J) positive results in affected samples; nondetects are not compromised by high MS recovery; thus, no actions are warranted. In accordance

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with some EPA Regional protocol, if MS/MSD %Rs are high, positive results are qualified as biased high (K).

4.6.13 Laboratory Duplicate Precision Criteria

Review Laboratory Control Sample Form 6 and associated raw data. Verify that one duplicate sample analysis was performed for each group of samples of a similar matrix within an SDG.

Control criteria used to evaluate aqueous laboratory duplicates are as follows:

- a. A control limit of 20% for relative percent difference when sample and duplicate results are >5X CRDL.
- b. A control limit of 1X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL.

Similarly, the following control criteria are generally used to evaluate solid laboratory duplicates:

- a. Control limit of 35% for the relative percent difference when sample and duplicate results are >5X CRDL.
- b. A control limit of 2X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL.

NOTE: The %RPD should reflect a difference of 200% and should not simply be recorded as noncalculable in instances where the sample result is positive but the laboratory duplicate result is nondetect. Overlooking this minor point may result in incomplete sample data qualification in some instances.

4.6.14 Laboratory Duplicate Precision Action

For any situation involving laboratory duplicate imprecision, qualify as estimated (J) positive results and (UJ) nondetects in affected samples.

NOTE: Laboratory duplicate data qualifications shall be matrix-specific but otherwise "across-the-board" for TAL inorganic analyses.

4.6.15 Laboratory Control Sample (LCS) Criteria

Review Laboratory Control Sample Form 7 and associated raw data. Verify that an LCS was analyzed for each matrix and for each batch of twenty samples or batch of samples digested (whichever is more frequent) within an SDG. The quality control criteria established for evaluation of aqueous LCS analyses are 80-120%. **NOTE:** An aqueous LCS is not required for mercury and cyanide analysis, and silver and antimony are not subject to quality control criteria. Verify that all solid "found values" fall within the EPA established control limits for soils.

4.6.16 Laboratory Control Sample (LCS) Action

- a. Aqueous
 1. In instances where aqueous LCS %R <80%, qualify positive results as estimated (J) and nondetects as (UJ). In accordance with some EPA Regional protocol, if LCS %Rs are low, positive results are qualified as biased low (L) and nondetects (UL).

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2. If aqueous LCS %R >120, qualify as estimated (J) positive results; nondetects are not compromised by high LCS recovery; thus, no actions are warranted. In accordance with some EPA Regional protocol, if LCS %Rs are high, positive results are qualified as biased high (K).

b. Solids

1. In instances where solid LCS %R found value is below lower quality control limit, qualify as estimated (J) positive results and (UJ) nondetects. In accordance with some EPA Regional protocol, if LCS %Rs are low, positive results are qualified as biased low (L) and nondetects (UL).
2. If solid LCS found value exceeds EPA upper limit for soils, qualify as estimated (J) positive results; nondetects are not compromised by high LCS recovery; thus, no actions are warranted. In accordance with some EPA Regional protocol, if LCS %Rs are high, positive results are qualified as biased high (K).

4.6.17 Method of Standard Additions (MSA) Criteria

Review MSA Form 8 and verify instrument linearity by checking that all calibration correlation coefficients (r) are greater than or equal to 0.995. MSAs for a particular analyte in a particular sample may be run more than once. Check reanalyses in instances where initial MSA analysis yields (r) <0.995. It is good practice to review one or two GFAA post-digestion spike (PDS) %Rs via reviewing unspiked and spiked sample concentrations and associated PDS recovery to verify that the Furnace Atomic Absorption Analysis Scheme has been followed.

4.6.18 Method of Standard Additions (MSA) Action

If calibration correlation coefficient (r) <0.995, qualify as estimated (J) positive result and/ or (UJ) nondetect in affected sample.

NOTE: The "Q" column on the Form 1 of the affected sample should contain an "S" flag for that particular analyte to indicate that the result was obtained using MSA. A "+" flag should also be recorded when the MSA correlation coefficient (r) <0.995. Review the appropriate Form I and amend if necessary.

4.6.19 ICP Serial Dilution Analysis Criteria

Review ICP Serial Dilutions Form 9 and associated raw data. Verify that a serial dilution was performed for each matrix and that all ICP analytes are included on the Form 9 with corresponding recovery calculations. Check the calculated Percent Difference (%D) column in instances where the diluted sample result is nondetected. In this situation, the laboratory should report a %D of 100% and not simply list the %D as noncalculable. Overlooking this minor point may result in incomplete sample data qualification in some instances. Amend the Form 9 if necessary. All %Ds for ICP serial dilution analyses should be <10% when concentrations of corresponding analytes in the original (undiluted) sample are minimally a factor of 50X IDL.

4.6.20 ICP Serial Dilution Actions

If %D >10% for an analyte, and the corresponding sample concentration is >50x IDL, qualify as estimated (J) positive results for that analyte in all samples of the same matrix. NOTE: The possibility of negative interference exists when the ICP serial dilution %D >10% and the diluted sample result is significantly > original (undiluted) sample result. Qualify as estimated (J) positive results and (UJ) nondetects in such instances.

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NOTE: In accordance with some EPA Regional protocol, the %D should be < 15%.

4.6.21 PA Analysis Run Logs Form 14s Criteria

The Form 14 serves several useful functions. It can be used to obtain sample analysis dates as noted in the heading of the page. Secondly, it is used to record any dilutions as applicable to ICP, GFAA, mercury, and cyanide analyses. And finally, it can be used to verify that GFAA PDS percent recoveries are within the 85-115% quality control limits. Additionally, the data reviewer should be careful to note that one and only one "X" flag has been used to indicate each reported field sample result or quality control sample result; this can be an area of frequent laboratory error.

4.6.22 PA Analysis Run Logs Form 14s Action

- a. If the PDS %R is <85%, qualify as estimated (J) the corresponding positive result and/or (UJ) nondetect in affected sample.
- b. If the PDS %R is >115%, qualify as estimated (J) the corresponding positive result in the affected sample; nondetects are not qualified based on high PDS %R.

4.6.23 Field Duplicate Precision Criteria

Field duplicates can be determined via Project Manager informational documents (i.e., sampling logs) or obtained from Chain-of-Custody (COC) forms. Field duplicates are generally identified as samples having identical sample collection times and dates.

In instances where field duplicate samples are included with the sample data set, the following control criteria are generally used to evaluate aqueous field duplicates:

- a. A control limit of 30% for relative percent difference when sample and duplicate results are >5X CRDL.
- b. A control limit of 2X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL.

Similarly, the following control criteria are generally used to evaluate solid field duplicates:

- a. A control limit of 50% for the relative percent difference when sample and duplicate results are >5X CRDL.
- b. A control limit of 4X CRDL for the difference between the sample values when sample and/or duplicate results are <5X CRDL.

NOTE: The %RPD should reflect a difference of 200% and should not simply be recorded as noncalculable in instances where the sample result is positive but the field duplicate result is nondetect. Overlooking this minor point may result in incomplete sample data qualification in some instances.

4.6.24 Field Duplicate Precision Action

For any situation involving field duplicate imprecision, qualify as estimated (J) positive results and (UJ) nondetects in affected samples.

NOTE: It is important to note in the letter text the cause of field duplicate imprecision (i.e., noncompliant %RPD or noncompliant difference between sample and duplicate results).

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Furthermore, field duplicate data qualifications shall be matrix-specific but otherwise "across-the-board" for TAL inorganic analyses.

4.6.25 Further GFAA Evaluations

It is necessary to review the raw data for GFAA analyses and verify that all Coefficients of Variation or Relative Standard Deviations (%RSDs) are <20% for reported sample results which exceed the CRDL.

- a. If the CV or %RSD exceeds 20% and the reported sample result is > CRDL, qualify as estimated (J) positive result in affected sample.

4.7 Deliverables Guidance

In addition to any specific USEPA Regional requirements (e.g. data validation memorandum, data summary spreadsheets, USEPA Regional worksheets), all laboratory data package quality control summary forms, sample Form I reports, method blank Form Is, and the Chain-of-Custody report must be given to the Data Validation Quality Assurance Officer (DV/QAO) for quality assurance review.

The validator should ensure that the format of the data validation deliverable is complete and correct (in accordance with the appropriate USEPA Regional or client requirements) and that the validation narrative is free of transcription and typographical errors before submitting all requested items for DV/QAO review.

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5.0 REFERENCES

Department of Defense (DoD) Environmental Data Quality Workgroup, 2006. Quality Systems Manual (QSM) for Environmental Laboratories, Final Version 3, January.

EPA540/R-04-004, U.S. EPA, 2004. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, October.

US EPA (U.S. Environmental Protection Agency), 2005. Test Methods for Evaluating Solid Waste (SW-846, Third Edition), Physical/Chemical Methods, as amended by Updates I, II, IIA, IIB, III, IIIA, and IIIB, June.

U.S. EPA, 2004. USEPA Contract Laboratory Program Statement of Work for Inorganic Analysis, Multi-Media, Multi-Concentration, ILM05.3, March.

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**APPENDIX A
SAMPLE CALCUATIONS**

Aqueous Samples:

Verify that the Form I matches the instrument printout.

Soil Samples:

$$\text{Concentration (mg/Kg)} = \frac{A \times D \times E}{B \times C} \times 1\text{L}/1000\text{ml} \times 1000\text{g}/1\text{Kg}$$

- A = Concentration from instrument printout (ug/L)
- B = Initial sample weight (g)
- C = % solids/100
- D = Dilution factor
- E = Final digestion volume (ml)



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability Tetra Tech NUS, Inc.	
Prepared Risk Assessment Department	
Approved D. Senovich <i>DS</i>	

Subject
 DATA VALIDATION - POLYCHLORINATED
 DIBENZODIOXINS AND POLYCHLORINATED
 DIBENZOFURANS FOR SOLID AND AQUEOUS
 MATRICES

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1.0 CLP DFLM 1.1/SW-846 METHODS 8280/8290

1.1 Applicability

Methods 8280, 8290 and CLP SOW DFLM1.1 are applicable for the determination of the tetra-, penta-, hexa-, hepta-, and octachlorinated congeners of dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) (by Gas Chromatography/Mass Spectrometry (GC/MS) via selective ion monitoring) in chemical wastes including fuel oils, sludges, fly ash, still bottoms, reactor residues, soil, and water. Methods 8280 and DFLM1.1 are low resolution GC/MS techniques while Method 8290 is a high resolution GC/MS technique.

1.2 Dioxin Data Package Deliverable Minimum Requirements

The following information must be present in data package prior to the validation effort:

- Appropriate Chain-of-Custody (COC) Form(s)
- Laboratory Case Narrative documenting any particular analytical anomalies encountered and sample description information (i.e., sample cross-reference identifications)
- Calibration Summaries
- Laboratory Control Sample and Duplicate forms
- Single Control Samples and Method Blank Results
- Matrix Spike/Matrix Spike Duplicates
- Retention Time Marker Solutions
- Internal and Recovery Standard Area Summaries

The appropriate laboratory liaison must be contacted immediately if any of the above items have been omitted from the data package.

1.3 Technical Data Evaluation

NOTE: Analysis of a fortified standard and blank may be submitted as evidence of compliant Performance Evaluation (PE) analyses as per region-specific requirements. The fortified standard will contain 2,3,7,8-TCDD at a known quantity while the fortified blank will contain 1,2,3,4-TCDD plus other known interferents. The recovery for 2,3,7,8-TCDD recognition must be within the EPA's 99% confidence interval.

1.4 Quality Control

1.4.1 Holding Times and Sample Preservation

All samples are to be extracted within 30 days of sample collection, and all subsequent analyses are to be conducted within 45 days from the date of collection. **NOTE:** Data qualification based upon holding time noncompliances is rare due to the minor effect of extended storage time on PCDD/PCDF quantitation resulting from the inherent persistence and known stability of these compounds. However, estimation of associated sample data based on holding time shall be subject to the professional judgment of the data validator.

Sample preservation shall be checked by referencing the appropriate Chain-of-Custody (COC) form(s) and verifying that all samples receiving PCDD/PCDF analysis were cooled to and stored at 4°C.

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1.4.2 Initial Calibration Verification

Review the average Relative Response Factors (RRFs) for all dioxin congeners by recalculating approximately 10% of the reported RRFs while also verifying proper use of quantitation ions. The following ions are specified for selective ion monitoring for PCDDs and PCDFs:

Analyte		Quantitation Ion	Confirmation Ions
PCDDs	Tetra	322	320
	Penta	356	354; 358
	Hexa	390	388; 392
	Hepta	424	422; 426
	Octa	460	458
PCDFs	Tetra	306	304
	Penta	340	338; 342
	Hexa	374	372; 376
	Hepta	408	406; 410
	Octa	444	442

Internal Standards

Analyte	Quantitation Ion	Confirmation Ion
¹³ C12-2,3,7,8-TCDD	334	332
¹³ C12-1,2,3,6,7,8-H _x CDD	404	402
¹³ C12-OCDD	472	470
¹³ C12-2,3,7,8-TCDF	318	316
¹³ C12-1,2,3,4,6,7,8-H _p CDF	420	422

Recovery Standards

Analyte	Quantitation Ion	Confirmation Ion
¹³ C12-1,2,3,4-TCDD	334	332
¹³ C12-1,2,3,7,8,9-H _x CDD	404	402

Next verify the acceptability of isotopic ratios as outlined in the following table:

Analyte		Selected Ions	Relative m/z
PCDDs	Tetra	320/322	0.65-0.89
	Penta	356/358	1.24-1.86
	Hexa	390/392	1.05-1.43
	Hepta	424/426	0.88-1.20
	Octa	458/460	0.76-1.02
PCDFs	Tetra	304/306	0.65-0.89
	Penta	340/342	1.24-1.86
	Hexa	374/376	1.05-1.43
	Hepta	408/410	0.88-1.20
	Octa	442/444	0.76-1.02

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Internal Standards

Analyte	Selected Ions	Relative m/z
13C12-2,3,7,8-TCDD	332/334	0.65-0.89
13C12-1,2,3,6,7,8-H _x CDD	402/404	1.05-1.43
13C12-OCDD	470/472	0.76-1.02
13C12-2,3,7,8-TCDF	316/318	0.65-0.89
13C12-1,2,3,4,6,7,8-H _p CDF	420/422	0.88-1.20

Recovery Standards

Analyte	Selected Ions	Relative m/z
13C12-1,2,3,4-TCDD	332/334	0.65-0.89
13C12-1,2,3,7,8,9-H _x CDD	402/404	1.05-1.43

Typically, the data reviewer can expect to associate the following congeners with their associated internal standards as follows:

Internal Standard #1 (13C12-2,3,7,8-TCDD)	TCDD, PeCDD
Internal Standard #2 (13C12-1,2,3,6,7,8-H _x CDD)	HxCDD, HpCDD
Internal Standard #3 (13C-OCDD)	OCDD, OCDF
Internal Standard #4 (13C12-TCDF)	TCDF, PeCDF
Internal Standard #5 (13C12-HpCDF)	HxCDF, HpCDF

Additionally, verify that the Relative Standard Deviation (%RSD) for all target compounds and internal standards is $\leq 15\%$.

Actions - Qualify as estimated, (J) positive results and (UJ) nondetects in affected samples if RSD is $>15\%$.

Window Defining Mix

This is a retention time check which must be run prior to the continuing calibration. The composition of the window defining mix may or may not be known. Review the following criteria:

- Peak separation must be $\leq 25\%$ valley criterion for TCDD isomers
- Peak separation must be \leq the 50% valley criterion for HxCDD isomers
- Multiple ion detection mass chromatograms and reconstructed ion chromatograms should be present for the window defining mix

Actions - Professional judgment (weighted primarily upon chromatographic expertise) must be employed when assigning data qualifications.

1.4.3 Continuing Calibration Verification

Evaluation of the CCV involves evaluating the Daily Standard (which is a standard that contains the required target compounds plus internal standards), versus the initial standard.

Verify that a Continuing Calibration Verification (CCV) was analyzed prior to sample analysis and at the beginning of each subsequent 12-hour period. A CCV must also be analyzed at the end of the final analysis period.

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The Signal-to-Noise ratio (S/N) for all internal standards must be >10:1. No quality control criteria exist to govern internal standard recovery; however, internal standard advisory recovery limits of 40-120% were established in earlier EPA validation protocol.

Verify that the internal standard area count in the sample is -50% to +100% of the internal standard area count in the associated daily standard.

Complete one Percent Recovery (%R_{is}) calculation for an internal standard as outlined in **equation A** below:

$$\text{Equation A: } \%R_{is} = \frac{(A_{is})(Q_{rs})}{(A_{rs})(RRF_{is})(Q_{is})} \times 100$$

where: A_{is} = area of the quantitation ion of the internal standard
A_{rs} = area of the quantitation ion of the recovery standard
Q_{is} = ng of internal standard
Q_{rs} = ng of recovery standard
RRF_{is} = Relative Response Factor for the internal standard as determined from the associated continuing calibration

An RRF shall be calculated for each congener in the CCV solution. A Percent Difference (%D) of 30% from the average RRF must be accomplished for the CCV. **NOTE:** Recalculate some (approximately 10%) of the continuing calibration RRFs for thoroughness.

Actions - Qualify associated sample data as estimated, i.e., (J) positive results and (UJ) nondetects in affected samples in instances where CCV %D >30%. Qualify as rejected (R) all associated sample data in instances where the internal standard S/N ratio <10:1.

1.4.4 Laboratory Method Blank Evaluations

Verify that a laboratory generated method blank was analyzed prior to sample analysis and for each matrix and extraction batch for all samples within an SDG. The laboratory method blanks should be free from contamination and/or interferences stemming from glassware involved in sample preparation and subsequent analytical procedures, associated reagents and solvents, etc. The following criteria shall be employed for evaluation of contaminant levels present in laboratory method blanks:

- The signal of any confirmed analyte present in a method blank must be <2% of the signal of the associated internal standard (based on peak height or peak area). Comparison of contaminants present in the blanks at levels below the calibration range (i.e., contaminants present at levels which constitute <2% of the respective internal standard) shall not require reanalyses as stipulated by the method.
- An action level of 5X the maximum contaminant level shall be used in instances of positive detections.
- The data reviewer should complete a detection limit verification calculation.
- Detection limits are sample-specific dependent upon the concentration of a given analyte to produce a signal with a peak height ≥ 2.5 X the background signal.
- The data reviewer shall consider all applicable sample weight, moisture content, and dilution factors prior to application of the aforementioned action level.

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- The data reviewer shall recalculate at least one Detection Limit (DL) using **equation B** as follows:

$$\text{Equation B: } DL = \frac{(2.5)(H_x)(Q_{is})}{(A_{is})(RRF_A)(W)}$$

where: A_{is} = area of the quantitation ion of the internal standard
 Q_{is} = ng of internal standard
 H_x = peak height of noise for the analyte's quantitation ion
 RRF_{is} = Relative Response Factor for the analyte as determined from the associated continuing calibration
 W = dry weight of the sample (g)

Actions - Effects on sample data and subsequent data qualifications shall be upon the professional judgment of the data reviewer, but the following general qualifying guidance shall be employed; Qualify as nondetected (U) any positive result less than the corresponding action level.

1.4.5 Duplicate Control Samples

The Duplicate Control Sample (DCS) is a well-characterized matrix which is spiked and analyzed at approximately 10% of the sample load in order to establish method-specific quality control limits. The DCS spike recovery quality control limits of 60-140% shall be employed. Additionally, the RPDs between control sample and duplicate shall be below 50%.

Actions - Qualify as estimated (J) positive results in affected samples when DCS spike recoveries are >140%. Qualify as estimated (J) positive results and (UJ) nondetects in affected samples when DCS spike recoveries are <60%. Qualify as estimated (J) positive results and (UJ) nondetects in affected samples when %RPD between control and duplicate sample exceeds 50%.

1.4.6 Matrix Spike/Matrix Spike Duplicate Review

Verify that a matrix spike has been analyzed for each matrix and batch of samples within an SDG.

Verify that the %RSD between matrix spike and duplicate injections is \leq 50%. Additionally, the following recovery limits shall be employed for the respective congeners:

Congener	Recovery Limits
TCDD	50-150%
PCDD	50-150%
HxCDD	50-150%
HpCDD	50-150%
OCDD	50-150%
TCDF	50-150%
PeCDF	50-150%
HxCDF	50-150%
HpCDF	50-150%
OCDF	50-150%

Actions - Qualify as estimated (J) only positive results in affected samples when the recovery exceeds the upper quality control limit. Qualify as estimated, (J) positive results and (UJ) nondetects in affected samples when the recovery is below the lower quality control limit.

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1.4.7 Chromatographic Performance and Evaluation

Verify that the recovery standard area counts are within -50% to +100% of the area counts in the respective daily check standard.

Examine chromatographic acceptability by checking the chromatographic base-line for fluctuation (i.e., raising or lowering), peak shape and resolution. Proper peak resolution between 13C-2,3,7,8-TCDD and 13C-1,2,3,4-TCDD (or 13C-2,3,7,8-TCDD and its closest eluting isomer), shall be attained at a threshold acceptability level of <25%.

Actions - Data qualification shall be based upon the professional judgment of the data reviewer.

1.4.8 Sample Quantitation

Confirm the quantitation of at least one Estimated Maximum Positive Concentration (EMPC). The laboratory will report an EMPC as opposed to a confirmed, definite positive hit in instances where the S/N \geq 2.5 for both the quantitation ion and confirmation ion for a given target isomer/analyte. The following equation shall be used to verify at least one EMPC calculation:

$$EMPC = \frac{(A_x)(Q_{is})}{(A_{is})(RRF_A)(W)}$$

where: A_x = area of the quantitation or confirmation ion, whichever is lower
 Q_{is} , A_{is} , RRF_A , and W are defined in the previous equation.

The data reviewer will also confirm at least one positive detection using the following equation:

$$C_A = \frac{(A_A)(Q_{is})}{(A_{is})(RRF_A)(W)}$$

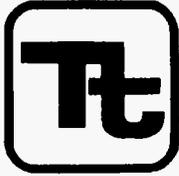
where: A_{is} , Q_{is} , RRF_A , and W are defined in previous equations
 C_A = analyte concentration (ng/g or ug/kg)
 A_A = analyte quantitation ion area

NOTE: EMPC values are estimates by definition. If these values are used for risk assessment, it must be understood that an EMPC value is "less certain" than positive results which are qualified (J), since the qualified results meet identification criteria while EMPCs do not.

1.5 Deliverables

In addition to any work-request requirements (e.g., data validation memorandum), all laboratory data package quality control summary forms, laboratory summaries of sample results and laboratory method blanks, and COCs must be provided to the Data Validation Quality Assurance Officer (DV/QAO) for quality assurance review.

The validator should ensure that the format of the data validation deliverable is complete and correct, and that the validation narrative is free of transcription and typographical errors before submitting all requested items for DV/QAO review.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved D. Senovich <i>[Signature]</i>	

Subject EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT

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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.

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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

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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.

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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.

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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 "popping" 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.

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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

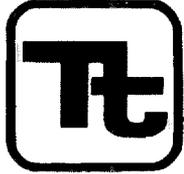
Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives 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.



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Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS

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1.0 PURPOSE

The purpose of this procedure is to provide a basic understanding of developing contour maps and the approaches used to identify and quantify the direction and rate of groundwater flow and contaminant plume movement.

2.0 SCOPE

This procedure provides only a general overview of the field techniques, mathematical and physical relationships and data handling procedures used for determining groundwater flow direction and rate. The references identified herein can provide a more complete explanation of particular methods cited, as well as a more comprehensive discussion on the interpretation of hydrogeologic data.

3.0 GLOSSARY

Aquifer - A geologic formation capable of transmitting usable quantities of groundwater to a well or other discharge point.

Aquitard - A geologic formation which retards the flow of groundwater due to its low permeability.

Confined Aquifer - An aquifer that is overlain and underlain by zones of lower permeability (aquitards). If the aquifer is "artesian," the potentiometric head of the aquifer at a given point is higher than the top of the zone comprising the aquifer at that point.

Equipotential Line - A line connecting points of equal elevation of the water table or potentiometric surface. Equipotential lines on the water table are also called water table contour lines.

Flow Line - A flow line indicates the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Flow Net - A diagram of groundwater flow showing flow lines and equipotential lines.

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous material to transmit water. Volume of water that will flow through a unit cross sectional area of porous material per unit time under a head gradient. Hydraulic conductivity is dependent upon properties of the medium and fluid.

Hydraulic Gradient (i) - The rate of change of hydraulic head per unit distance of flow at a given point and in the downgradient direction.

Hydraulic Head - The height to which water will rise inside a well casing, equal to the elevation head plus the pressure head. In a well screened across the water table, hydraulic head equals the elevation head, as the pressure head equals 0. In wells screened below the water table in an unconfined aquifer or screened at any interval within a confined aquifer, the head is the sum of the elevation of the aquifer (the elevation head) and the fluid pressure of the water confined in the aquifer (the pressure head).

Potentiometric (piezometric) Surface - A hypothetical surface that coincides with the static level of the water in an aquifer (i.e., the maximum elevation to which water will rise in a well or piezometer penetrating the aquifer). The term "potentiometric surface" is usually applied to confined aquifers, although the water table is the potentiometric surface of an unconfined aquifer.

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

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Water Table - The surface in the groundwater system at which the fluid pressure is equal to atmospheric pressure (i.e., the net pressure head is zero) and below which all strata are saturated with water.

4.0 RESPONSIBILITIES

Project Hydrogeologist - The project hydrogeologist has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist (with the concurrence of 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 of data points needed and which wells shall be used for 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 - All supporting 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.

5.0 PROCEDURES

5.1 Potentiometric Surface Mapping

5.1.1 Selection of Wells

All wells used to prepare a flow net in a plan or map view should represent the same hydrogeologic unit, be it aquifer or aquitard. All water level measurements used shall be collected on the same day, preferably within 2-3 hours. This is especially important when working in an area where groundwater levels are tidally influenced or influenced by pumping.

The recorded water levels, monitoring-well construction data, site geology, and topographic setting must be reviewed to ascertain that the wells are completed in the same hydrogeologic unit and to determine if strong vertical hydraulic gradients may be present. Such conditions will be manifested by a pronounced correlation between well depth and water level, or by a difference in water level between two wells located near each other but set to different depths or having different screen lengths. Professional judgment of the hydrogeologist is important in this determination. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished in a chosen vertical zone of the hydrogeologic unit can be used.

At least three wells must be used to provide an estimation of the direction of groundwater flow; information from many more wells are needed to provide an accurate contour map. Generally, shallow systems require data from more wells than deep systems for accurate contour mapping. Potentiometric surface mapping for shallow flow systems also requires water level measurements from nearby surface water bodies.

5.1.2 Water Level Measurements

After selection of the wells to be used for mapping, the next step in determining the direction of groundwater flow is to obtain water level elevations from the selected points. In addition, any other readily available wells/surface water bodies should be measured to ensure that sufficient data are available for interpretation purposes.

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Elevations are obtained from measurements of the depth to water in a monitoring well or piezometer taken from the top of the well casing (see SOP GH-1.2) and then referencing the elevation of the casing to a chosen and consistent datum point, usually mean sea level. Subtracting the depth to water from the casing elevation provides the elevation of the potentiometric surface. Elevations of points and areas of groundwater discharge or recharge such as springs, seeps, streams, rivers, and lakes also need to be determined, typically through staff gauge measurements. Comparison of these elevations, which represent hydraulic heads, will reveal the direction of flow because groundwater flows from areas of high head to areas of low head.

5.1.3 Construction of Equipotential Lines

Graphical methods available for depicting the flow of groundwater include the use of equipotential lines and flow lines to construct potentiometric surface maps and vertical flow nets. If the hydrogeologic system consists of a water table aquifer and one or more confined aquifers, separate contour maps should be prepared for each aquifer system. Water table maps should be developed using water level measurements obtained from monitoring wells screened at the unsaturated-saturated interface. Water level measurements collected from monitoring wells screened in the deeper portions of an unconfined aquifer should generally be contoured as a separate potentiometric surface map. Surface water discharge or recharge features are contoured in the water table system. Vertical flow nets should be constructed using a cross section aligned parallel to the direction of groundwater flow. All water level measurements along this cross section, both deep and shallow, are used in developing equipotential lines and flow lines for the flow net.

To construct equipotential lines, water level elevations in the chosen wells are plotted on a site map. Other hydrogeologic features associated with the zone of interest -- such as seeps, wetlands, and surface-water bodies -- should also be plotted along with their elevations.

The data should then be contoured, using mathematically valid and generally accepted techniques. Linear interpolation is the most commonly used technique. However, quadratic interpolation or any technique of trend-surface analysis or data smoothing is acceptable. Computer-generated contour maps may be useful rough mapping of large data sets; however, final, detailed mapping must always be performed by hand by an experienced hydrogeologist. Contour lines shall be drawn as smooth, continuous lines which never cross one another.

Inspect the contour map, noting known features, such as pumping wells and site topography. The contour lines must be adjusted utilizing the professional judgment of the hydrogeologist in accordance with these features. Closed contours should be avoided unless a known groundwater sink (i.e., pumping well) or mound exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must be evident in the contour plot.

5.1.4 Determination of Groundwater-Flow Direction

Flow lines shall be drawn so that they are perpendicular to equipotential lines. Flow lines will begin at high head elevations and end at low head elevations. Closed highs will be the source of additional flow lines. Closed depressions (i.e., wells) will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

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5.2 Groundwater Flow Considerations

Groundwater movement is an integral part of the hydrologic cycle. Recharge to the shallow groundwater environment generally occurs by infiltration of precipitation through an upper unsaturated soil zone. Movement is downward under the force of gravity until the water reaches the saturated zone of the water table aquifer. Once water is part of the water table aquifer, movement is controlled by differences in hydraulic head, with movement from areas of high head to areas of low head. Areas of low head include natural discharge areas such as springs, lakes, rivers, and, ultimately, the ocean. These features can be considered as outcrops of the water table. Points of low head also are created by pumping wells.

Local head differences and consequent vertical flow patterns within an aquifer can be detected by well clusters. A well cluster consists of several adjacent wells, generally installed within a few feet of each other, and screened at different depths. Variations in water levels in these closely spaced wells indicates the vertical component of groundwater flow within an aquifer, provided that the wells are all screened within the same aquifer.

The number, location, and extent of geologic units and their properties with regard to aquifer or aquitard characteristics must be understood to properly interpret water level data gathered from the monitoring system. This firm understanding of the hydrogeologic system must be developed through a program of borings, wells, and interpretation of subsurface geology. The adequacy of the positions and depths of borings/wells used to define relevant subsurface hydrogeologic conditions must also be assessed. The location of surface water discharge or recharge points must be considered. Surface water features influence the system, as flow is most likely toward them (if they are discharge points) or away from them (if they are recharge points). Man-made discharge or recharge features such as pumping or injection wells, ditches, and trenches can also affect the flow of groundwater.

5.3 Determination of Flow Rate

Darcy's Law states that the quantity of water flowing through a geologic material is dependent upon the permeability of the material, the hydraulic gradient, and the cross sectional area through which the water flows. This relation is expressed in the equation:

$$Q = KiA$$

where:

- Q = volume of water flowing through the cross sectional area of the formation (L^3/T).
- K = hydraulic conductivity (L/T).
- i = hydraulic gradient (L/L , i.e., dimensionless).
- A = cross sectional area of formation being considered (L^2).

The relation is similar to one used in stream flow measurements where:

$$Q = VA$$

where:

- Q = discharge from the cross sectional area of a stream or pipe (L^3/T).
- V = average velocity of flowing water (L/T).
- A = cross sectional area through which water flows (L^2).

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The velocity of water movement in a geologic formation depends on the specific formation properties and the head differences across the formation. This relation is defined in the equation:

$$V = \frac{Ki}{n}$$

where:

- V = average linear velocity of groundwater through the formation (L/T)
- K = hydraulic conductivity (L/T)
- i = hydraulic gradient (dimensionless)
- n = porosity (expressed as a fraction).

Values of porosity for several geologic materials are given in Attachment A. More accurate and specific values of porosity can be obtained by laboratory analysis of a formation sample or from an unconfined aquifer pumping test.

Hydraulic conductivity is related to the permeability of the formation and depends on the size and interconnection of the pore spaces. In isotropic and homogeneous formations, the hydraulic conductivity will be the same vertically and horizontally. In anisotropic formations, horizontal and vertical conductivity can be markedly different and the vertical hydraulic conductivity can be up to several orders of magnitude lower than the horizontal hydraulic conductivity. Typically, most formations are anisotropic with horizontal hydraulic conductivities at least several times as high as the vertical hydraulic conductivities.

Generally, hydraulic conductivities are high for sands, gravels, and limestone containing large solution cavities and low for silts, clays, and tightly fractured rock. Attachment A gives values of hydraulic conductivity for several geologic materials. More accurate values can be obtained during field testing of aquifers or from laboratory measurements on undisturbed cores. Results from field testing usually provide higher (and more representative) hydraulic conductivities than laboratory testing because full-scale field testing includes the effects of the formational macrostructure (i.e., secondary permeability due to jointing or fractures) which is not reflected in the testing of a small sample in the laboratory.

The hydraulic gradient, *i*, is determined from field measurements of hydraulic head obtained from water level measuring points. Do not measure gradient from well to well; measure across equipotential lines that are drawn based on the well (and other) data. Once a potentiometric surface map has been generated using the hydraulic head data, the hydraulic gradient can be calculated using the following formula:

$$i = \frac{dh}{dl}$$

where:

- dh = change in head (L)
- dl = distance between equipotential lines (L)

The hydraulic gradient along any flow line can be calculated from a potentiometric surface map by dividing the change in head by the length of the flow line, typically beginning and ending at equipotential lines. The longer the distance over which the head change is measured, the more representative the gradient is of overall conditions.

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When chemical solutes are traveling in groundwater, as in cases of groundwater contamination, the calculated groundwater velocity may predict migration rates in excess of what is actually observed. The difference in chemical versus water velocities may be due to attenuation or biodegradation of the chemical species in the aquifer. Attenuation is most often caused by adsorption of the chemical contaminant onto the formation grains or matrix. The result is that the chemical does not appear at the downgradient sampling point as quickly as the velocity calculation predicts. An equation to correct for this attenuation is:

$$V_c = V_w / (1 + K_d P_b / n)$$

where:

V_c	=	velocity of the chemical solute flow (L/T)
V_w	=	velocity of groundwater flow (L/T)
P_b	=	formation mass bulk density (M/L ³)
n	=	formation porosity (expressed as a fraction)
K_d	=	distribution coefficient = (L ³ /M)

The K_d is equal to the mass of solute per unit mass of solid phase divided by the concentration of solute in solution. The term in the denominator is known as the retardation factor.

Density and/or viscosity differences between water and contaminants can also cause velocity determination errors. Light hydrocarbons such as gasoline are less dense than water and consequently float on the water table. These contaminants can migrate along the water table surface at rates faster or slower than the rate of groundwater movement, depending on specific conditions, and may also volatilize into unsaturated soil pore spaces. Oils are more viscous than water and will typically migrate more slowly due to the viscosity difference. Contaminants denser than water such as heavy hydrocarbons (e.g., coal tar) or chlorinated compounds (e.g., TCE, PCE) tend to sink to the bottom of an aquifer if present in concentrations exceeding their solubility limit (these chemicals are often referred to as dense, nonaqueous phase liquids, or DNAPLs if present as a separate-phase liquid). Here, the contamination may move at faster or slower rates than the overlying groundwater or may actually move in a direction opposite to that of the groundwater, depending on the geologic characteristics of the aquifer base and direction of dip of the underlying aquitard.

Other factors involving the physicochemical interaction between the chemical and the groundwater, such as dilution (mixing contaminated water or chemicals with additional quantities of groundwater) and dispersion (molecular diffusion of the chemical throughout the groundwater regime), can also affect the observed rates of travel of contaminants in groundwater. In addition to such physicochemical characteristics, all of the aquifer and aquitard properties and groundwater flow characteristics described above must be known so that adequate and accurate estimations of the extent and rate of groundwater contaminant migration can be developed.

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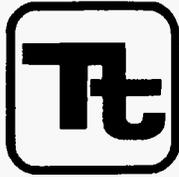
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ATTACHMENT A

**GENERALIZED POROSITY AND HYDRAULIC CONDUCTIVITY
VALUES FOR GEOLOGIC MATERIALS**

Material	Porosity Range (%)	Hydraulic Conductivity Range	
		cm/sec	ft/day
Gravel	30-40	10^{-1} to 10^{-2}	280 to 2.8×10^5
Coarse sand (clean)	30-40	10^{-1} to 1	280 to 2,800
Medium sand (clean)	35-45	10^{-2} to 10^{-1}	28 to 280
Fine sand (clean)	40-50	5×10^{-4} to 10^{-2}	1.4 to 28
Silty sand	25-40	10^{-5} to 10^{-2}	0.03 to 280
Glacial Till	Variable	10^{-10} to 10^{-4}	3×10^{-7} to 0.3
Unweathered Clay/Shale	45-55 (clay)	10^{-7} to 10^{-4}	3×10^{-4} to 0.3 (horizontal)
		10^{-10} to 10^{-6}	3×10^{-7} to 3×10^{-3} (vertical)
Karst Limestone	---	10^{-4} to 10^{-1}	0.3 to 2,800
Fractured Igneous/Metamorphic Rocks	---	10^{-6} to 10^{-1}	3×10^{-3} to 280
Sandstone	5-30	10^{-8} to 10^{-4}	3×10^{-5} to 0.3

Source: References 1 and 2



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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.

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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.

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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.

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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.

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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.

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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 lid 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 TD

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~~When drilling and installing a well in a confined aquifer, special 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~~

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

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~~4/27/11~~

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 ~~TD~~ Uses

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~~4/27/11~~

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

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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

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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

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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 [®] | 5 | Lo-Carbon Steel |
| 2 | Stainless Steel 316 | 6 | Galvanized Steel |
| 3 | Stainless Steel 304 | 7 | Carbon Steel |
| 4 | PVC 1 | | |

* 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 [®] | 5 | PE Conventional |
| 2 | Polypropylene (PP) | 6 | Plexiglas/Lucite (PMM) |
| 3 | PVC Flexible/PE Linear | 7 | Silicone/Neoprene |
| 4 | Viton [®] | | |

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Source: Barcelona et al., 1983

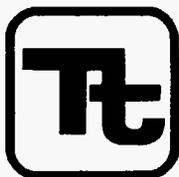
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ATTACHMENT B

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.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Health & Safety		
Approved	D. Senovich <i>[Signature]</i>		

Subject
UTILITY LOCATING AND EXCAVATION CLEARANCE

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

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4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

Site Personnel – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.
- 2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scars and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility

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locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.
4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.
5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain
6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.
7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.
8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

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5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

<u>Nominal Voltage</u>	<u>Minimum Clearance</u>
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

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Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

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Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting

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debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey all be placed as close as possible to the cleared hand excavation. It is important to note that a backhoe loader or backhoe loader digger must not be used in this type of hand excavation activity.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily-available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a non-conductive tile probe, should always be in conjunction with suitable utility locating detection equipment.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.
2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.
4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

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- ~~5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.~~

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4
 OSHA 29 CFR 1926(b)(2)
 OSHA 29 CFR 1926(b)(3)
 TtNUS Utility Locating and Clearance Policy
 TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
 TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
 TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

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**ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES**



American Public Works Association
2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625
Phone (816) 472-6100 • Fax (816) 472-1610
Web www.apwa.net • E-mail apwa@apwa.net

**ONE-CALL SYSTEMS INTERNATIONAL
CONDENSED DIRECTORY**

Alabama Alabama One-Call 1-800-292-8525	Iowa Iowa One-Call 1-800-292-8989	New Jersey New Jersey One Call 1-800-272-1000
Alaska Locate Call Center of Alaska, Inc. 1-800-478-3121	Kansas Kansas One-Call System, Inc. 1-800-344-7233	New Mexico New Mexico One Call System, Inc. 1-800-321-2537 Las Cruces- Dona Ana Blue Stakes 1-888-526-0400
Arizona Arizona Blue Stake 1-800-782-5348	Kentucky Kentucky Underground Protection Inc. 1-800-752-6007	New York Dig Safely New York 1-800-862-7962 New York City- Long Island One Call Center 1-800-272-4480
Arkansas Arkansas One Call System, Inc. 1-800-482-8998	Louisiana Louisiana One Call System, Inc. 1-800-272-3020	North Carolina The North Carolina One-Call Center, Inc. 1-800-632-4949
California Underground Service Alert North 1-800-227-2600 Underground Service Alert of Southern California 1-800-227-2600	Maine Dig Safe System, Inc. 1-888-344-7233	North Dakota North Dakota One-Call 1-800-795-0555
Colorado Utility Notification Center of Colorado 1-800-922-1987	Maryland Miss Utility 1-800-257-7777 Miss Utility of Delmarva 1-800-282-8555	Ohio Ohio Utilities Protection Service 1-800-362-2764 Oil & Gas Producers Underground Protect'n Svc 1-800-925-0988
Connecticut Call Before You Dig 1-800-922-4455	Massachusetts Dig Safe System, Inc. 1-888-344-7233	Oklahoma Call Okie 1-800-522-6543
Delaware Miss Utility of Delmarva 1-800-282-8555	Michigan Miss Dig System, Inc. 1-800-482-7171	Oregon Oregon Utility Notification Center/One Call Concepts 1-800-332-2344
Florida Sunshine State One-Call of Florida, Inc. 1-800-432-4770	Minnesota Gopher State One Call 1-800-252-1168	Pennsylvania Pennsylvania One Call System, Inc. 1-800-242-1776
Georgia Underground Protection Center, Inc. 1-800-282-7411	Mississippi Mississippi One-Call System, Inc. 1-800-227-6477	Rhode Island Dig Safe System, Inc. 1-888-344-7233
Hawaii Underground Service Alert North 1-800-227-2600	Missouri Missouri One-Call System, Inc. 1-800-344-7483	South Carolina Palmetto Utility Protection Service Inc. 1-888-721-7877
Idaho Dig Line Inc. 1-800-342-1585 Kootenai County One-Call 1-800-428-4950 Shoshone - Benewah One-Call 1-800-398-3285	Montana Utilities Underground Protection Center 1-800-424-5555 Montana One Call Center 1-800-551-8344	South Dakota South Dakota One Call 1-800-781-7474
Illinois JULIE, Inc. 1-800-892-0123 Digger (Chicago Utility Alert Network) 312-744-7000	Nebraska Diggers Hotline of Nebraska 1-800-331-5666	Tennessee Tennessee One-Call System, Inc. 1-800-351-1111
Indiana Indiana Underground Plant Protection Service 1-800-382-5544	Nevada Underground Service Alert North 1-800-227-2600	
	New Hampshire Dig Safe System, Inc. 1-888-344-7233	

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ATTACHMENT 1 (Continued)

Texas

Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah

Blue Stakes of Utah
1-800-662-4111

Vermont

Dig Safe System, Inc.
1-888-344-7233

Virginia

Miss Utility of Virginia
1-800-552-7001
Miss Utility (Northern Virginia)
1-800-257-7777

Washington

Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating
Council
509-456-8000

West Virginia

Miss Utility of West Virginia, Inc.
1-800-245-4848

Wisconsin

Diggers Hotline, Inc.
1-800-242-8511

Wyoming

Wyoming One-Call System, Inc.
1-800-348-1030
Call Before You Dig of Wyoming
1-800-849-2476

District of Columbia

Miss Utility
1-800-257-7777

Alberta

Alberta One-Call Corporation
1-800-242-3447

British Columbia

BC One Call
1-800-474-6886

Ontario

Ontario One-Call System
1-800-400-2255

Quebec

Info-Excavation
1-800-663-9228

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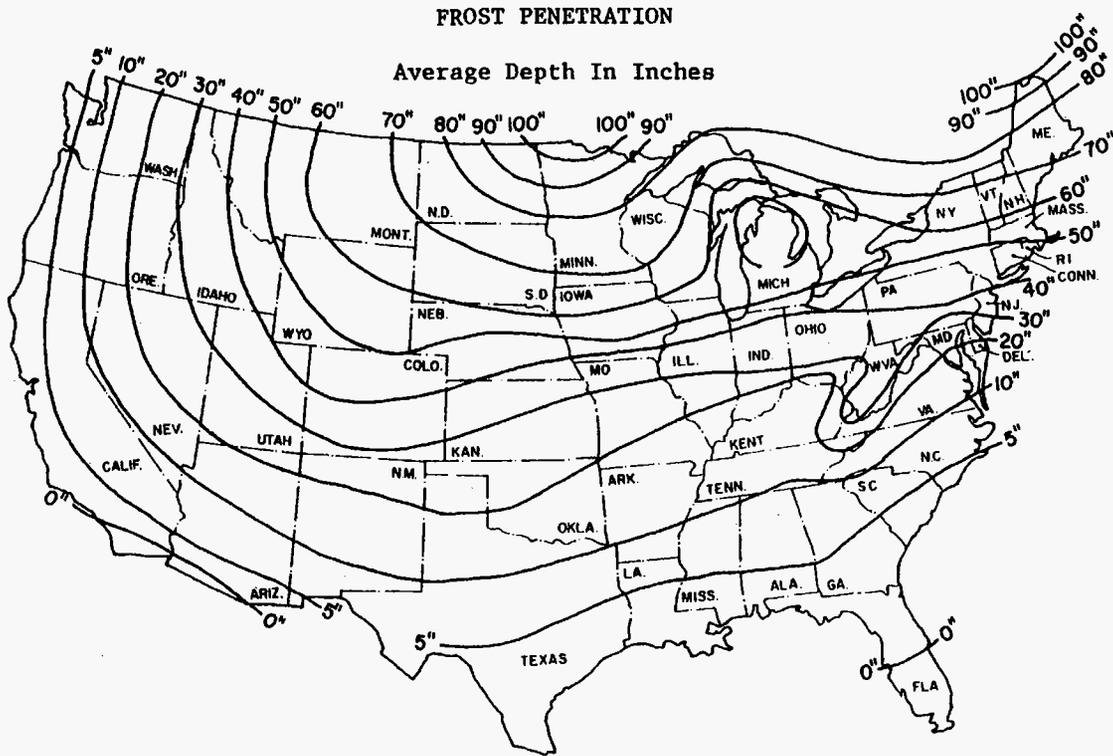
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ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



Courtesy U.S. Department Of Commerce

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**ATTACHMENT 3
UTILITY CLEARANCE FORM**

Client: _____ Project Name: _____
 Project No.: _____ Completed By: _____
 Location Name: _____ Work Date: _____
 Excavation Method/Overhead Equipment: _____

1. Underground Utilities Circle One
- a) Review of existing maps? yes no N/A
 - b) Interview local personnel? yes no N/A
 - c) Site visit and inspection? yes no N/A
 - d) Excavation areas marked in the field? yes no N/A
 - e) Utilities located in the field? yes no N/A
 - f) Located utilities marked/added to site maps? yes no N/A
 - g) Client contact notified yes no N/A
 Name _____ Telephone: _____ Date: _____
 - g) State One-Call agency called? yes no N/A
 Caller: _____
 Ticket Number: _____ Date: _____
 - h) Geophysical survey performed? yes no N/A
 Survey performed by: _____
 Method: _____ Date: _____
 - i) Hand excavation performed (with concurrent use of utility
 detection device)? yes no N/A
 Completed by: _____
 Total depth: _____ feet Date: _____
 - j) Trench/excavation probed? yes no N/A
 Probing completed by: _____
 Depth/frequency: _____ Date: _____

2. Overhead Utilities Present Absent
- a) Determination of nominal voltage yes no N/A
 - b) Marked on site maps yes no N/A
 - c) Necessary to lockout/insulate/re-route yes no N/A
 - d) Document procedures used to lockout/insulate/re-route yes no N/A
 - e) Minimum acceptable clearance (SOP Section 5.2): _____

3. Notes:

Approval:
 _____ Date _____
 Site Manager/Field Operations Leader

c: PM/Project File
 Program File

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**ATTACHMENT 4
OSHA LETTER OF INTERPRETATION**

Mr. Joseph Caldwell
Consultant
Governmental Liaison
Pipeline Safety Regulations
211 Wilson Boulevard
Suite 700
Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

***Question:** Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.*

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

Background

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651 (Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

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ATTACHMENT 4 (Continued)

When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means. (emphasis added).

Therefore, “acceptable means” must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either “other acceptable means” or “safe and acceptable means.” The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified “careful probing or hand digging” as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language “to allow other, *equally effective means* of locating such installations.” The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used where the utilities have not been marked and detection equipment is not being used – “probing with hand-held tools.” This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

OSHA received two comments * * * and input from ACCSH [OSHA’s Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping ‘such as probing with hand-held tools’ from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of “acceptable means” in the final provision.

Non-conductive hand tools are permitted

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a “shooter” (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, when used with appropriate caution, is an “acceptable means” for locating underground utilities.

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ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director
Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA's interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at <http://www.osha.gov>.



TETRA TECH

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	Tom Johnston <i>T.E. Johnston</i>		

Subject
GROUNDWATER SAMPLE ACQUISITION AND
ONSITE WATER QUALITY TESTING

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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.

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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.

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- 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.

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- 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.

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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.

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- 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.

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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).

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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.

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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.

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- 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.

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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

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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)

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- 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.

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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.

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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.

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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

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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.

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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.

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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).

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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.

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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.

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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.

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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 from 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

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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 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

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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).

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- 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.

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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 $\pm 10\%$
 - Temperature $\pm 10\%$
 - Turbidity less than 10 NTUs
 - DO $\pm 10\%$
 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:

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- 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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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

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PURGING EQUIPMENT SELECTION
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Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/L 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®, Tefze®	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.

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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.

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TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>ds</i>		

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NATURAL ATTENUATION PARAMETER COLLECTION

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1.0 PURPOSE

The purpose of this document is to provide general reference information regarding natural attenuation parameter and methodology selection, sample collection, and a general understanding of the sample results.

2.0 SCOPE

This document provides information on selection of appropriate groundwater natural attenuation parameters, selection of sampling methods for these parameters, techniques for onsite field analysis of select parameters, and some basic understanding of the field sample results. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling practices and techniques. To a limited extent, it shall also facilitate the understanding and interpretation of the sampling results. It addresses field procedures for collection of data at sites with organic groundwater contaminants (e.g., chlorinated and petroleum hydrocarbons) to the extent practical. The focus of this document is on natural attenuation, not enhanced bioremediation.

The techniques described shall be followed whenever applicable, noting that site-specific conditions, project-specific objectives, local, state, and federal guidelines may be used as a basis for modification of the procedures noted herein. The intent of this document is to supplement the local, state, and federal guidance documents and manufacturer's analytical methods referenced in Section 6.0. It is not intended for this document to supersede this guidance or information. Please note that natural attenuation is a relatively dynamic science with ongoing research in the science and engineering community. It is important that data collectors and interpreters use the most recent regulatory guidance, which may be updated on a periodic basis from that noted in Section 6.

3.0 GLOSSARY

Aerobe: Bacteria that use oxygen as an electron acceptor.

Anaerobe: Organisms that can use electron acceptors other than molecular oxygen to support their metabolism.

Anoxic groundwater: Groundwater that contains oxygen in concentrations less than about 0.5 mg/L. This term is synonymous with the term anaerobic.

Anthropogenic: Man-made.

Cometabolism: The process in which a compound is fortuitously degraded by an enzyme or cofactor produced during microbial metabolism of another compound.

Daughter product: A compound that results directly from the biotic or abiotic degradation of another. For example, *cis*-1,2-dichloroethene (*cis*-1,2-DCE) is a common daughter product of trichloroethene (TCE).

Diffusion: The process whereby molecules move from a region of higher concentration to a region of lower concentration as a result of Brownian motion.

Dispersion: The tendency for a solute to spread from the path that it would be expected to follow under advective transport.

Electron acceptor: A compound capable of accepting electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an electron acceptor. Electron acceptors are compounds that are relatively oxidized and include oxygen, nitrate, iron(III), manganese(IV), sulfate, carbon dioxide, or in some cases chlorinated aliphatic hydrocarbons such as tetrachloroethene (PCE), TCE, DCE and vinyl chloride (VC).

Electron donor: A compound capable of supplying (giving up) electrons during oxidation-reduction reactions. Microorganisms obtain energy by transferring electrons from an electron donor such as an organic compound (or sometimes a reduced inorganic compound such as sulfide) to an

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electron acceptor. Electron donors are compounds that are relatively reduced and include fuel hydrocarbons and native organic carbon.

Metabolic byproduct: A product of the reaction between an electron donor and an electron acceptor. Metabolic byproducts include volatile fatty acids, daughter products of chlorinated aliphatic hydrocarbons, methane, and chloride.

Oxic groundwater: Groundwater that contains oxygen in concentrations greater than about 0.5 mg/L.

Oxidation/reduction reaction: A chemical or biological reaction wherein an electron is transferred from an electron donor (donor is oxidized) to an electron acceptor (acceptor is reduced).

Predominant terminal electron-accepting process: The electron-accepting process (oxygen reduction, nitrate reduction, iron(III) reduction, etc.) that sequesters the majority of the electron flow in a given system.

Reductive dechlorination: Reduction of a chlorine-containing organic compound via the replacement of chlorine with hydrogen.

Respiration: The process of coupling the oxidation of organic compounds with the reduction of inorganic compounds such as oxygen, nitrate, iron(III), manganese(IV), and sulfate.

Seepage velocity: The average velocity of groundwater in a porous medium.

Substrate: A compound used by microorganisms to obtain energy for growth. The term can refer to either an electron acceptor or an electron donor.

4.0 RESPONSIBILITIES

Project Manager (PM) / Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this standard operating procedure (SOP).

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

Site Manager (SM) / Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Project Geologist - is primarily responsible for the proper acquisition of the groundwater samples. He/she is also responsible for the actual analyses of onsite water quality samples, as well as instrument calibration, care, and maintenance. When appropriate, such responsibilities may be performed by other qualified personnel (e.g., field sampling technicians or site personnel).

5.0 PROCEDURES

5.1 General

Natural attenuation includes physical, chemical, and biochemical processes affecting the concentrations of dissolved contaminants in groundwater. These processes may include advection, dispersion, volatilization, dilution, sorption to aquifer solids, and/or precipitation or mineralization of compounds. Of greatest importance are those processes that lead to a reduction in contaminant mass (by degrading or destroying contaminants) such as biodegradation. These biochemical processes remove organic contaminants from the aquifer by destruction. Depending on the type of contaminant, particularly the organic contaminant (e.g., petroleum hydrocarbons or chlorinated organic solvents), the biochemical environment in the aquifer will vary. The biochemical environment within the aquifer influences and is influenced by the activities of aquifer microbiota. Specific types of microbiota, working singly or in complex consortia, may use organic contaminants as part of their normal cell functions. Natural

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attenuation monitoring is designed to measure indicators of the biochemical environment within the aquifer and, with direct and indirect lines of evidence and associated chemical concentration data, evaluate the likely fate (i.e., transformation, destruction, dilution, attenuation, etc.) of organic contaminants.

5.2 Planning for Natural Attenuation Sampling

The first step in preparing a natural attenuation investigation is to develop a site-specific conceptual model. The first step in development of this model is the analysis and review of available site-specific characterization data. The development and refinement of this model should be supplemented with additional data as needed. The data should include but is not limited to:

- Geologic and hydrogeologic information in three dimensions
- Nature, extent, and magnitude of contamination
- Location and presence of potential receptors to contamination

Lines of Evidence

Several lines of evidence are used to determine whether natural attenuation is working. The most compelling, primary evidence is decreasing groundwater contaminant concentrations over time. Decreasing concentration trends can be demonstrated in several ways including:

- Isoconcentration maps of the dissolved plume over time wherein the extent of the plume is either stable or decreasing.
- Time series plots of contaminant concentrations within a well illustrating a clear downward trend.
- Contaminant concentration profiles in a series of monitoring wells along a groundwater flow path illustrating decreasing concentrations beyond that attributable to dilution and dispersion.

Secondary, or supporting, lines of evidence include:

- Analytical data showing production and subsequent destruction of primary contaminant breakdown products.
- Geochemical data indicating that the biochemical environment is favorable for the appropriate microbiota.
- Geochemical data that indicate the aquifer microbiota are active.

Monitoring Well Location and Sampling Frequency

The number and locations of wells required to monitor natural attenuation will depend on the physical setting at each location. One possible array of monitoring wells is illustrated in Attachment A. In this scenario, one well is used to monitor conditions upgradient of the source, one well is located in the source area, and several wells are used to define and monitor the downgradient and lateral extent of the dissolved plume. At a minimum, there should be at least one upgradient well (ideally with no contamination present), one well in the source area, one well downgradient from the source area in the dissolved plume, and one downgradient well where contaminant concentrations are below regulatory criteria. Note that the number and locations of monitoring wells will vary depending on the site complexity and site objectives.

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Sampling frequency will be dictated by the ultimate use of the data and site-specific characteristics. Contaminant concentrations may be used to define statistically meaningful trends in contaminant concentrations. The sampling frequency may be defined by the hydrogeologic and/or geochemical conditions as well as the proposed statistical method for data analysis. For example, groundwater flow and contaminant characteristics (e.g., seepage velocity and contaminant loading) may dictate the sample frequency. Regardless of the factors, sampling frequency and duration will need to establish the range of natural chemical variability within the aquifer. After a sufficient amount of data has been collected and the geochemical conditions are understood, the frequency of sampling may be reduced. See Section 5.4 for additional information on sample collection and frequency.

5.3 Selection of Natural Attenuation Parameters

Natural attenuation via biodegradation depends on the nature of the organic contaminants and the oxidation-reduction (redox) environment within the aquifer. Simply stated, if the contaminants are fuels, biodegradation will be most effective if the redox conditions are aerobic or oxidizing. If the contaminants are chlorinated solvents, the biodegradation will be most effective (in the source and near source areas) if redox conditions in the aquifer are anaerobic or reducing.

Several parameters are needed to evaluate whether natural attenuation is taking place and, if so, the rate at which it may be occurring. The primary parameter providing direct evidence of natural attenuation is the aqueous concentrations of parent and daughter volatile organic compounds. More specifically, a decrease in parent products, an increase in daughter products, evidence that the plume is stable or shrinking in size, and overall decline in contaminant concentrations is direct evidence of natural attenuation. Natural attenuation or geochemical parameters that provide information about the redox conditions in the aquifer include:

- Dissolved oxygen
- Nitrate/nitrite
- Dissolved manganese
- Iron
- Sulfate/sulfide
- Methane
- Oxidation-reduction potential (ORP)

Secondary parameters that indicate biological activity in the aquifer and thereby support the natural attenuation evaluation include:

- Dissolved hydrogen
- Alkalinity
- Dissolved carbon dioxide

The concentrations of natural attenuation parameters are used to define the aquifer redox conditions. It is important to record and document the presence or absence (i.e., measurable or not measurable concentration) of certain natural attenuation parameters. The presence or absence of a certain substance may be sufficient to indicate the redox condition within the aquifer. By reference to Attachment B, which illustrates the typical sequence of biologically mediated redox reactions in natural systems, it is apparent that, for example, sulfate reduction (producing dissolved sulfide in groundwater) does not operate in an aerobic environment. Therefore, measurable sulfide should not be present if there is also dissolved oxygen at concentrations indicating an aerobic environment. Attachment B also illustrates the redox potential (measured in millivolts) associated with the redox reactions. ORP readings, also in millivolts, measured during well purging, may be compared with the range of values in Attachment B but with caution. Redox potentials measured with a platinum electrode in natural water samples may be misleading, especially when biologically mediated reactions are important, because many of the critical

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reactions in Attachment B do not generate a response in the electrode. Dissolved hydrogen concentration ranges associated with important redox reactions are also indicated in Attachment B. Because dissolved hydrogen is actually used by microbiota during redox reactions, its concentration may provide an additional indicator of the overall redox condition in the aquifer.

Attachments C and D tabulate the natural attenuation parameters for chlorinated volatile organic compound and petroleum hydrocarbon plumes, respectively. The parameters listed in these tables are organized in order of importance. Parameters selected for analysis shall be determined based on site conditions, project-specific plans, and/or other criteria established for the project. Based on these criteria, it is possible that all of the parameters may be selected.

5.4 Selection of Natural Attenuation Analytical Methods and Procedures

There are many analytical methods available to measure concentrations of the natural attenuation parameters discussed in the previous sections. Attachment E summarizes the sample methodologies, sampling equipment needed, sample volume, container, preservation, and holding time requirements. This table also summarizes the detection limits and the detection ranges for each method. A number of factors should be considered when selecting the appropriate sample analytical methodology including the required parameters, appropriate detection ranges for each compound, cost, and ease of use in the field. For example, when determining the correct methodology for measuring concentrations of total sulfide, the metabolic byproduct of sulfate reducing conditions, it is important to analyze for each of the forms of sulfide (H_2S , S^{2-} , and HS^-). Also, when the detection limit of the selected method is exceeded, another method may be considered, or the sampler may be able to dilute the sample (per manufacturer's instructions) to quantify it within the detected range. In terms of cost, some parameters are very time consuming when performed in the field. Without sacrificing sample integrity it may be more appropriate to select a methodology performed in a fixed-base laboratory. Finally, in terms of ease of use, certain field methods are generally easier compared to other methods. Using simpler methods may result in better quality sample results and increased sample repeatability without sacrificing sample integrity. For example, in some cases CHEMetrics Titret® Titration Ampule kits may be a good alternative to other hand digital titration methods.

The sample technicians should be aware that based on geochemical conditions recorded in the field, certain geochemical parameters may not have positive detections. For example, if dissolved oxygen concentrations indicate aerobic conditions then it is unlikely that dissolved hydrogen is present (see Section 5.10 for additional information). Another example is alkalinity. If the pH of the groundwater sample is less than 4.5, then it is unlikely that alkalinity will be measurable. Despite the potential for non-detect results, in cases such as those described above, all parameters should be collected in the field based upon project plans. The value in collecting the parameters in the future shall be determined by the project hydrogeologist and/or geochemist in accordance with the projects planning documents data quality objectives (DQO) and the items discussed in Section 5.2.

5.5 Procedures for Sample Collection

Groundwater sample collection for natural attenuation sampling should be performed using low flow purging and sampling techniques. These techniques are described in detail in SOP SA-1.1. Low flow purging and sampling procedures should be used to ensure the collection of a sample that is "representative" of the water present in the aquifer formation. Minimizing stress on the aquifer formation during low flow purging and sample collection ensures that there are minimal alternations to the water chemistry of the sample. The criteria used in the purging process should include minimization of drawdown in the well, stabilization of applicable indicator parameters, and evacuation of a sufficient amount of purge volume in accordance with SOP SA-1.1, project plans, and/or applicable regulatory guidance.

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Groundwater purging and sampling for natural attenuation should be performed using submersible pumps (e.g., bladder pumps) in accordance with SOP SA-1.1. However, in accordance with project plans and applicable regulatory guidance, peristaltic pumps may also be used for this purpose. Limitations of and factors associated with using these devices should be considered (see SOP SA-1.1 for more information). As a result of difficulties in collecting "representative" groundwater samples, bailers should not be used for the collection of natural attenuation samples.

It is critical that disturbance and aeration of samples monitored and collected at the well head are minimized. As a result, a flow-through sampling cell and a direct reading meter shall be used for the measurement of well stabilization indicator parameters (e.g., pH, conductivity, temperature, dissolved oxygen, turbidity, and ORP) at the well head. The pump effluent tubing should be placed at the bottom of the flow-through cell allowing effluent water from the cell to discharge at the top of the meter (above the detector probes) to minimize the agitation of water in the cell.

Documentation of the purging process shall be recorded during and at the completion of purging as discussed in Section 5.8. Immediately following the purging process and before sampling, all applicable indicator parameters must be measured and recorded on the appropriate sample log sheets as discussed in Section 5.8.

After all of the purging requirements have been met, groundwater sampling and natural attenuation data collection can begin. Monitoring wells will be sampled using the same pump and tubing used during well purging.

5.6 Procedures for Field Sample Analysis

Each of the field and fixed-base laboratory sample parameters requires different sampling procedures and holding times. Attachment E presents parameter-specific requirements for sampling, analysis, and storage of all of the parameters and methods sampled as part of natural attenuation analysis.

Due to parameter procedure and holding times, it is important to consider the sequence of sample collection and analysis. Generally speaking, with the exception of volatile organic compounds, field parameters shall be analyzed first followed by fixed-base laboratory sample collection. All samples will be collected in a sequence and manner that minimizes volatilization, oxidation, and/or chemical transformation of compounds. As a result, the following sample and analysis order should be followed:

- | | |
|---|------------------------------------|
| 1. Volatile organic compounds | 8. Nitrate / Nitrite |
| 2. Dissolved oxygen | 9. Dissolved manganese |
| 3. Alkalinity | 10. Semivolatile organic compounds |
| 4. Dissolved carbon dioxide | 11. Other dissolved metals |
| 5. Dissolved ferrous iron | 12. Total metals |
| 6. Dissolved sulfide (hydrogen sulfide and sulfide) | 13. All other constituents |
| 7. Dissolved hydrogen, methane, ethene, and ethane | |

Field-analyzed parameters should be collected and immediately analyzed directly from the pump effluent per the requirements on Attachment E and manufacturer's recommendations. Care should be taken to minimize any unnecessary disturbance, aeration, or agitation of the sample prior to analysis. It is not acceptable to collect and store samples that are to be analyzed immediately at the well head in a temporary holding container (e.g., open topped pitcher) to be analyzed at a later time.

The manufacturer's procedure manual for each of the field-based analyses shall be maintained in the field during the entire sampling program. The procedures give a detailed explanation of how to perform each particular method and include information on sampling, storage, accuracy checks, interferences, reagents, and apparatus needed to perform each analysis.

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5.7 Procedures for Quality Assurance and Quality Control Field Sample Analysis

Accuracy and precision checks shall be performed to check the performance of the reagents, apparatus, and field analytical procedures per the manufacturer's recommendations. The accuracy checks should include the use of standard solutions (i.e., standard addition), as appropriate. The manufacturer's field test kit manual provides details on how to perform each of the accuracy checks for each parameter where applicable. Refer to Section 6.0 for manufacturer contact information.

Precision checks must include the performance of duplicate analysis. When using a colorimeter, precision checks may also include reagent blank corrections and standard curve adjustments as recommended by the manufacturer. Field duplicate results shall be performed and evaluated for relative percent difference (RPD) at a rate of 1 per 10 samples or as determined by the project plans. The RPD can be calculated as follows:

$$RPD = \left| \frac{\text{First result} - \text{Second result}}{\text{Mean arithmetic (average) of first and second result}} \right| \times 100$$

If the RPD exceeds 50 percent, it is required that the test be performed again to verify the result. The duplicate results shall be documented in the 'Notes' section for that specific parameter on the appropriate sample logsheet (see Section 5.8).

If a colorimeter (e.g., HACH DR-890 or equivalent) is used for parameter analysis, an instrument performance verification test using absorbance standards may also be performed to ensure the meter is providing accurate measurements.

The following table lists examples of the types and frequencies of accuracy checks required for each parameter. Refer to the manufacturer's instructions for information regarding other analyses.

Parameter	Method	Standard Solution	Field Duplicate	Reagent Blank Correction
Alkalinity	CHEMetrics K-9810, -15, -20	None	1 per 10	None
Carbon dioxide	CHEMetrics K-1910, -20, -25	None	1 per 10	None
Dissolved oxygen	CHEMetrics K-7501, -12	None	1 per 10	None
Ferrous iron	HACH DR-890	None	1 per 10	None
Nitrite	HACH DR-890	1 per round	1 per 10	1 per lot
Nitrate	HACH DR-890	1 per round	1 per 10	1 per lot
Sulfide	HACH DR-890	None	1 per 10	None
Hydrogen sulfide	HACH HS-C	None	1 per 10	None

Prior to analysis, the expiration dates of reagents shall be checked. If the reagents have exceeded their expiration date or shelf life, the reagents shall be replaced. If deviations from the applicable analytical procedure are identified, the deviations shall be corrected and the associated samples re-analyzed. If problems are identified with the reagents, apparatus, or procedures, data interferences may be present. Interferences may also be due to other factors (e.g., pH, presence or concentration of other ions, turbidity, temperature, etc.) that may interfere with the sample result. The manufacturer's procedures (e.g., Hach, 1999) should be reviewed prior to analysis to avoid or minimize such interferences. Associated problems

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or suspected interferences shall be documented in the 'Notes' section of the sample logsheet. Often, interferences cannot be avoided. In these cases, the sampler should be aware of these potential interferences and document them properly.

5.8 Documentation Procedures for Field Sample Analysis

Field results shall be properly documented in the field as noted in SOP SA-6.3. The sample log sheet titled "Field Analytical Log Sheet, Geochemical Parameters" shall be prepared for each sample collected and analyzed in the field. A copy of this form can be found as Attachment F of this SOP. Other field log sheets (e.g., low flow purge log sheet, groundwater sample logsheet, etc.) shall also be completed in accordance with SOP SA-6.3.

Specific information shall also be recorded in the project logbook. This information shall include, but is not limited to, the test kit name and model number, lot number and expiration date of the test kit and reagents used, serial number of the instrument (e.g., colorimeter) used for the analysis, and results of the quality assurance and quality control field sample analysis. Because environmental conditions and changes in those conditions may affect the field analytical results, it is important to document the site conditions (weather, temperature, etc.) at the time of sampling in the logbook in accordance with SOP SA-6.3.

5.9 Waste Handling and Disposal

Several of the test kits listed in Attachment E require the use of chemicals and materials that must be properly handled and disposed of in a proper and responsible manner. Refer to specific manufacturer's guidance for handling and disposal practices. See also Section 6.0 for more detailed and complete information. Handling and disposal of these items should be conducted in accordance with all local, state, and federal guidelines.

5.10 Understanding Field Sample Analytical Results

Natural attenuation data interpretation is complicated by the complex inter-relationships of various parameters. The complexity reflects the myriad of biochemical processes. Real-time evaluation of field analytical data can be misleading because a full interpretation often requires combining the field analytical results with fixed-base laboratory results. Regardless, some simple observations and data interpretations in the field may provide insights about the monitoring system or early warnings about sample collection and handling problems.

Data collected from the designated upgradient monitoring well is the baseline from which other interpretations are made. Field analytical data will indicate that the upgradient environment is either oxidizing or reducing. The redox condition within the upgradient area of the aquifer may be natural or impacted by other contaminant source areas (see Section 5.2 for upgradient well selection). Regardless, the redox condition of the upgradient groundwater will influence the source area. Changes in field analytical results from the upgradient well to the source area well will be reflected in samples from monitoring wells further downgradient.

The general characteristics of the two redox environments are summarized in the following table.

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Aerobic/Oxidizing	Anaerobic/Reducing
<ul style="list-style-type: none"> • Measurable dissolved oxygen (>1 to 2 ppm) • Measurable nitrate • No measurable dissolved manganese • No measurable dissolved ferrous iron • Measurable dissolved sulfate • No measurable dissolved sulfide • No measurable dissolved methane • No measurable dissolved hydrogen 	<ul style="list-style-type: none"> • No measurable dissolved oxygen (<1 ppm) • No measurable nitrate • Measurable dissolved manganese • Measurable dissolved ferrous iron • No measurable dissolved sulfate • Measurable dissolved sulfide • Measurable dissolved methane • Measurable dissolved hydrogen

Transitional environments between these two extremes may have intermediate characteristics and are actually quite common. Because reactions are mediated by biological systems, equilibrium (the basis for the figure in Attachment B) conditions within the aquifer should not be expected. For example, sulfate reduction environments may occur in close proximity to methanogenic environments, and this natural attenuation data may be difficult to interpret. Carefully collected and analyzed field measurements and sample collections for fixed-base laboratory analyses are designed to characterize the aquifer environment along the continuum between strongly aerobic and strongly anaerobic. Because the land surface environment is generally more oxidizing than any groundwater environment, sample handling at the point of collection and analysis is extremely important in preserving the chemical integrity of the groundwater sample.

6.0 REFERENCES

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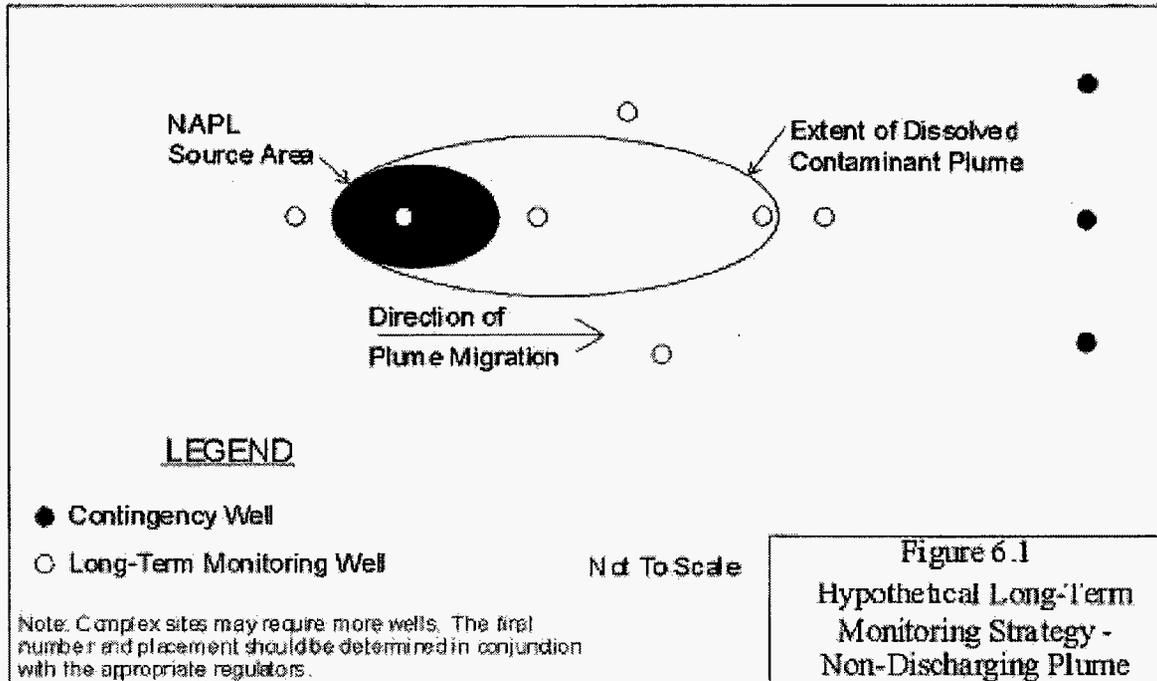
USEPA, 1997. Draft EPA Region 4 Suggested Practices for Evaluation of a Site for Natural Attenuation (Biological Degradation) of Chlorinated Solvents; Version 3.0. November.

USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, USEPA OSWER Directive 9200.4-17P, April 21, 1999

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ATTACHMENT A

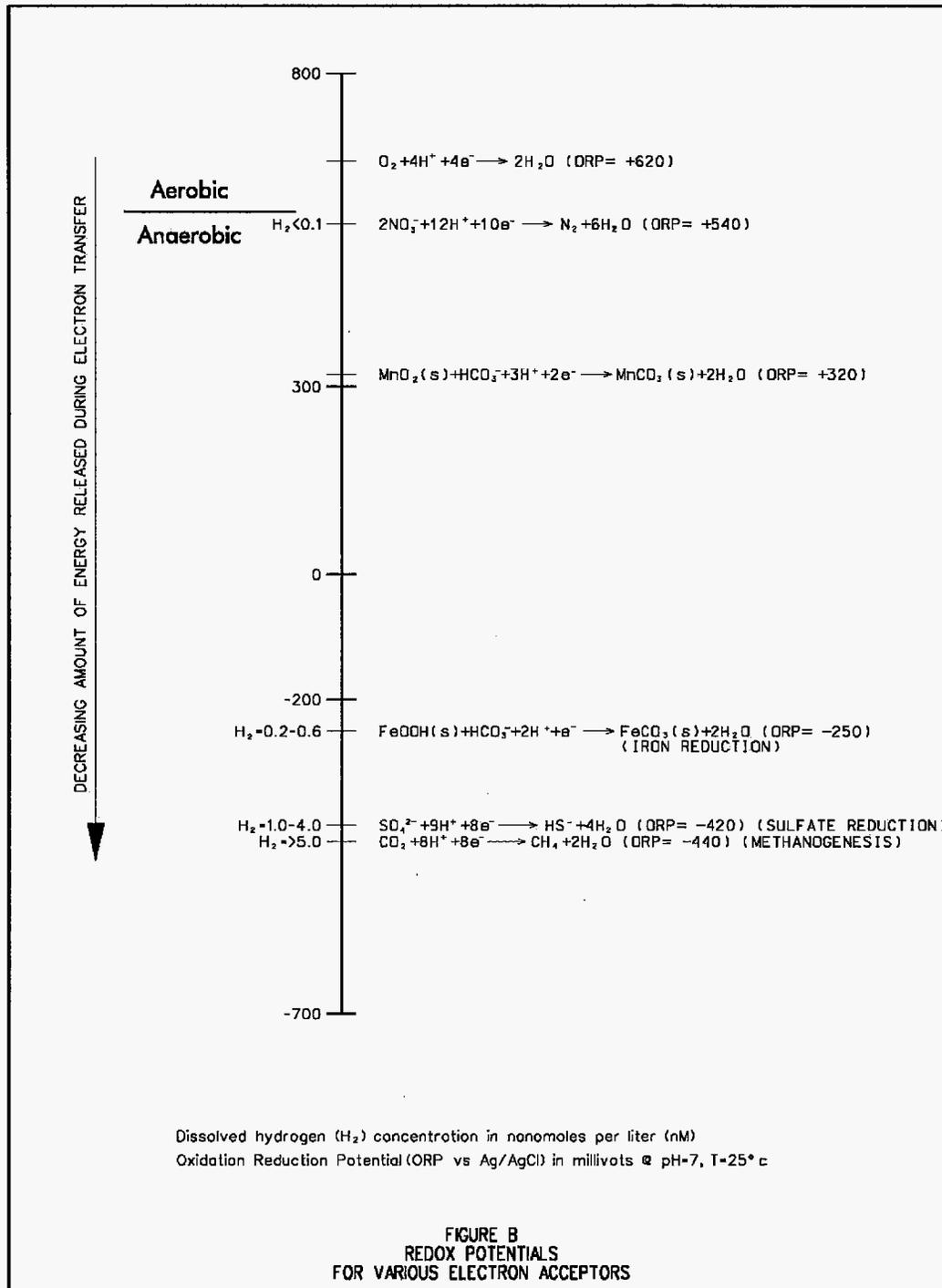
HYPOTHETICAL LONG-TERM MONITORING STRATEGY



Taken from: Department of the Navy, 1998, Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities, Prepared by Todd Weidemeier and Francis Chappelle.

ATTACHMENT B

REDOX POTENTIALS FOR VARIOUS ELECTRON ACCEPTORS



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ATTACHMENT C

NATURAL ATTENUATION PARAMETERS FOR CHLORINATED VOLATILE ORGANIC COMPOUND PLUMES SCREENING PROCESS SUMMARY FOR REDUCTIVE (ANAEROBIC) DECHLORINATION

Potential Electron Donors	Electron Acceptors:	Reduced Species:	Related Dechlorination Pathway:
Native total organic carbon (TOC) Anthropogenic carbon (e.g., leachate) Fuel hydrocarbons (e.g., BTEX) Lightly chlorinated solvents (DCE/VC)	Dissolved Oxygen	⇒ Carbon Dioxide (CO ₂)	~ DCE → VC → CO ₂
	Manganese (Mn ⁴⁺)	⇒ Manganese (Mn ²⁺)	~ DCE → VC
	Nitrate (NO ₃)	⇒ Nitrite (NO ₂)	~ DCE → VC
	Ferric Iron (Fe ³⁺)	⇒ Ferrous Iron (Fe ²⁺)	~ DCE → VC → CO ₂
	Sulfate (SO ₄)	⇒ Sulfide (S ²⁻ , HS ⁻ , H ₂ S)	~ TCE → DCE → VC → Ethene
	Carbon Dioxide (CO ₂)	⇒ Methane (CH ₄)	~ PCE → TCE → DCE → VC → Ethene

Geochemical Parameter List:

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (e.g., benzene, toluene, ethylbenzene, and xylene; BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe ²⁺)	F	Product of iron reduction	1
Sulfate [and sulfide (S ²⁻)]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H ₂ S)	F	Common product of sulfate reduction	1
Methane, ethane, ethene	L	Product of methanogenesis; daughter products of reductive dechlorination	1
Chloride	L	Ultimate daughter product of reductive dechlorination	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance, temperature, turbidity	F	General water quality determination	1
Carbon dioxide (CO ₂)	F	Anaerobic electron acceptor (methanogenesis); biotic respiration indicator	2
Alkalinity/DIC	F	Buffering capacity; biotic respiration indicator	2
Hydrogen, dissolved	L	Fingerprint for characterizing electron acceptor pathway - indicator of what redox is occurring	2
TOC - upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Volatile fatty acids	L	Determination of anthropogenic carbon used as an electron donor	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended). See Attachment E for details regarding analytical methods.

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ATTACHMENT D

**NATURAL ATTENUATION PARAMETERS FOR
PETROLEUM HYDROCARBON PLUMES
SCREENING PROCESS SUMMARY FOR OXIDATIVE (AEROBIC) DEGRADATION**

Parameter	Field or Lab	Rationale	Importance
Volatile organic compounds	L	Source products; daughter products; electron donors (BTEX)	1
Dissolved oxygen	F	Primary electron acceptor (respiration); an/aerobic indicator	1
Nitrate (and nitrite), dissolved	F or L	Anaerobic electron acceptor (and product of nitrate reduction)	1
Manganese, dissolved	F or L	Anaerobic electron acceptor	1
Ferrous Iron (Fe ²⁺)	F	Product of iron reduction	1
Sulfate [and Sulfide (S ⁻²)]	F or L	Common anaerobic electron acceptor (product of sulfate reduction)	1
Sulfide (H ₂ S)	F	Common product of sulfate reduction	1
TOC - upgradient groundwater	L	Electron donor	1
ORP, pH, specific conductance temperature, turbidity	F	General water quality determination	1
Dissolved methane (CH ₄)	L	Product of methanogenesis	1
Anions: chloride (Cl), nitrate (NO ₃), nitrite (NO ₂), phosphate (PO ₄), sulfate (SO ₄)	L		1
TOC - Upgradient soil	L	Input to analytical NA models; quantifies soil-water distribution coefficient and retardation factor	2
Biological oxygen demand (BOD)	L	Understanding of aquifer oxygen demand	3
Chemical oxygen demand (COD)	L	Understanding of aquifer oxygen demand	3

Importance: 1=Most important; 3=Least important (depending on DQOs, all may be recommended).

See Attachment E for details regarding analytical methods.

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ATTACHMENT E
GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUMES, CONTAINERS,
PRESERVATION, HOLDING TIMES, AND DETECTION RANGES
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Alkalinity	CHEMetrics K-9810, K-9815, K-9820 -ASTM D 1067-92 -EPA 310.1	Titret® Titration Ampules / Hydrochloric Acid, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine total alkalinity. Filter if turbid (>10 NTU).	10-100 (K-9810) 50-500 (K-9815) 100-1000 (K-9820)	N/A	10 50 100-
Alkalinity	Fixed-base lab -EPA 310.1	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 14 days. Filter if turbid.	N/A	N/A	N/A
Alkalinity / Dissolved Inorganic Carbon	HACH AL-DT -HACH 8203 -SM 2320 / SM 403	Digital Titration / Hydrochloric Acid, Phenolphthalein (P) and Total (M)	Field. Follow test kit instructions. Avoid agitation and analyze at well head to determine carbonate, bicarbonate, and hydroxide ions. Filter if turbid as recommended by manufacture. May use a pH meter for colored samples.	10-4000	N/A	10
Arsenic	Fixed-base lab -SW-6010 B	N/A	1 liter glass or polyethylene container, HNO ₃ to pH ≤ 2. 6 months.	N/A	N/A	N/A
Biochemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	2 liter HDPE. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Carbon Dioxide, dissolved	CHEMetrics K-1910, K-1920, K-1925 -ASTM D 513.82 -SM 4500-CO ₂ -C	Titret® Titration Ampules / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Avoid agitation and analyze at well head.	10-100 (K-1910) 100-1000 (K-1920) 250-2500 (K-1925)	N/A	10 100 250
Carbon Dioxide, dissolved	Fixed-base lab -VOA water sample (Vaportech)	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Carbon Dioxide, dissolved	Fixed-base lab -Microseeps gas stripping cell	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Carbon Dioxide, dissolved	HACH CA-DT -HACH 8205 -Mod. SM 406	Digital Titration / Sodium Hydroxide, Phenolphthalein	Field. Follow test kit instructions. Do not aerate or agitate. Analyze at well head.	10-1000	N/A	10
Chemical Oxygen Demand	Fixed-base lab -EPA 410.1	N/A	125 mL HDPE. H ₂ SO ₄ to pH <2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chloride (Cl)	Fixed-base lab -EPA 300	N/A	100 to 250 mL in glass or plastic container. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Chlorine - Total (Cl ₂)	HACH DR-850 -HACH 8167 -SM 4500-Cl	Colorimeter / DPD Method	Field. Follow test kit instructions.	0.02-2.00	± 0.01 mg/L with a 1.00 mg/L chlorine solution.	1
Conductance, Specific	Field Meter -SW-9050 A	Direct Reading Meter	100 to 250 mL in glass or plastic container. Analyze immediately.	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Ethane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A

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GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER,
PRESERVATION, HOLDING TIME, AND DETECTION RANGES
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Ethene, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Ethene, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Fraction Organic Carbon (foc)-Soil Upgradient Saturated Soil	Fixed-base lab -Walk-Black -SW-846 9060	N/A	200 gram glass jar. Cool to 4°C. Analyze within 14 days.	N/A	N/A	N/A
Hydrogen, dissolved	Fixed-base lab -Microseeps or Vapor Tech gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial.	N/A	N/A	N/A
Iron, ferrous (Fe ²⁺)	HACH DR-850 -HACH 8146 -Mod. SM 315 B	Colorimeter 1, 10 Phenanthroline	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-3.00	±0.017 mg/L with a 2.00 mg/L Fe ²⁺ solution.	0.03
Iron, ferrous (Fe ²⁺)	HACH IR-18C -Mod. SM 315 B	Color Disc 1, 10 Phenanthroline	Field. Follow test kit instructions. Analyze immediately at well head. Filter if turbid (>10 NTU) as recommended by the manufacture.	0-10	N/A	0.2
Iron, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Manganese (Mn ²⁺)	HACH DR-850 -HACH 8034 -CFR 44(116) 34193	Colorimeter / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-20.0	+ 0.19 mg/L with a 10.00 mg/L Mn solution.	0.12
Manganese (Mn ²⁺)	HACH MN-5 -Mod. SM 319 B -CFR 44(116) 34193	Color Disc / Cold Periodate Oxidation	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-3	N/A	0.1
Manganese, total dissolved (Filtered)	Fixed-base lab -SW-846 6010B	N/A	250 mL in plastic container. Field filter to 0.45 µ. HCl to pH <2. Cool to 4°C. Analyze within 6 months.	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Methane, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Nitrate (NO ₃)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours.	N/A	N/A	N/A
Nitrate (NO ₃)	HACH DR-850 -HACH 8192 -Mod. EPA 353.2	Colorimeter / Cadmium Reduction	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Pretreatment required if nitrite is present.	0-0.50	± 0.03 mg/L with a 0.25 mg/L of nitrate nitrogen (NO ₃ ⁻ N) solution.	0.01
Nitrite (NO ₂)	Fixed-base lab -EPA 300	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A

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**GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER,
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Nitrite (NO ₂ ⁻)	HACH DR-850 -HACH 8507 -Mod. EPA 354.1 -Mod. SM 419 -CFR 44(85) 25595	Colorimeter / Diazotization	Field. Follow test kit instructions. Avoid agitation and analyze at well head. Filter if turbid as recommended by the manufacture.	0-0.350	± 0.001 mg/L with a 0.250 mg/L nitrite nitrogen solution.	0.005
Nitrogen, dissolved	Fixed-base lab -Microseeps gas stripping cell -Vaportech VOA water sample	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required for Microseeps. Ship in glass septum vial (Microseeps) or VOA vial (Vaportech).	N/A	N/A	N/A
Nitrogen, Total Kjeldahl	Fixed-base lab -EPA 351.2	N/A	500 mL plastic/glass container. Cool to 4°C. H ₂ SO ₄ to pH ≤ 2. Analyze within 28 days.	N/A	N/A	N/A
Oxidation Reduction Potential	Field Meter - ASTM D-1498	Direct Reading Meter	Field. Do not aerate. Gently agitate probe using flow over or flow-through method. Analyze immediately at well head.	N/A	N/A	N/A
Oxygen, dissolved	CHEMetrics K-7501, K-7512 -ASTM D 5543-94 -ASTM D 887-92	CHEMets® Vacuum Vials / Rhodazine D and Indigo Carmine	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 (K-7501) 1-12 (K-7512)	N/A	0.025 1
Oxygen, dissolved	Fixed-base lab -VOA water sample, Vaportech -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	40 mL in VOA vial. 2 to 3 vials by (Vaportech).	N/A	N/A	N/A
Oxygen, dissolved	Fixed-base lab -Microseeps gas stripping cell -RSK SOP-147 & 175	GC-ECD/RGD/FID Detector	Field bubble-strip sampling required. Ship in glass septum vial (Microseeps only).	N/A	N/A	N/A
Oxygen, dissolved	HACH OX-DT -HACH 8215 -SM 4500-O-G	Digital Titration / Azide Modification of Winkler Digital Titration Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	1-10	N/A	1
Oxygen, dissolved	HACH DR-850 (AccuVac Ampules) LR HRDO Method	-Indigo Carmine Method -Rhodazine D Method	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-0.8 ppm 0-10 ppm	0.01 ppm 0.1 ppm	N/A
Oxygen, dissolved	Field Meter	Direct Reading Meter	Analyze immediately at well head. Avoid agitation and analyze immediately at well head. Used for well stabilization measurement parameter only.	N/A	N/A	N/A
pH	Field Meter -SW 9040B	Direct Reading Meter	Analyze immediately at well head.	N/A	N/A	N/A
Phosphate (ortho)	Fixed-base lab -EPA 300	Ion Chromatography	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Phosphate, potassium	Fixed-base lab -SV-846 6010B	Inductively Coupled Plasma	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Salinity	Field Meter	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A
Sulfate (SO ₄ ²⁻)	Fixed-base lab	N/A	250 mL plastic container. Cool to 4°C. Analyze within 48 hours. Filter if turbid as recommended by the manufacture.	N/A	N/A	N/A
Sulfate (SO ₄ ²⁻)	HACH DR-850 -HACH 8051 -EPA 375.4	Colorimeter / Turbimetric SulfaVer 4	Field. Follow test kit instructions. Filter if turbid as recommended by the manufacture.	0-70	± 0.5 mg/L with a 50 mg/L sulfate solution.	4.9
Sulfide (Hydrogen Sulfide, H ₂ S)	HACH HS-C -HACH Proprietary -Mod. SM 426 C	Color Chart / Effervescence of H ₂ S through sulfide reactive paper.	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-5	N/A	0.1
Sulfide (S ²⁻)	CHEMetrics K-9510 -SM 4500-S ²	CHEMets® Vacuum Vials / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head.	0-1 1-10	N/A	0.1 1

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ATTACHMENT E

**GEOCHEMICAL SAMPLING PARAMETERS - METHODS, EQUIPMENT, VOLUME, CONTAINER,
 PRESERVATION, HOLDING TIME, AND DETECTION RANGES
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Parameter	Method / Reference	Equipment / Method Chemistry	Sample Volume, Container, Preservation, & Holding Time	Range (mg/L)	Precision (mg/L)	Estimated Detection Limit (mg/L)
Sulfide (S ²⁻)	Fixed-base lab -EPA 376.1/376.2	N/A	1 liter in plastic container, no headspace. NaOH to pH >9. Cool to 4°C. Avoid agitation and analyze within 7 days.	N/A	N/A	N/A
Sulfide (S ²⁻)	HACH DR-850 -HACH 8131 -SM 4500-S ²	Colorimeter / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-0.70	± 0.02 mg/L with a 0.73 mg/L sulfide solution.	0.01
Sulfide (S ²⁻)	HACH HS-WR -SM 4500-S ²	Color Disc / Methylene Blue	Field. Follow test kit instructions. Avoid agitation and analyze immediately at well head. Pretreatment required for turbid samples as recommended by the manufacture.	0-11.25	N/A	0.1-2.5
Temperature	Field Meter / Thermometer - E 170.1	Direct Reading Meter / Thermometer	Analyze immediately.	N/A	N/A	N/A
Total Organic Carbon (TOC)-Groundwater	Fixed-base lab -E 415.1	N/A	125 mL HDPE. H ₂ SO ₄ to pH < 2.0. Cool to 4°C. Analyze within 28 days.	N/A	N/A	N/A
Turbidity	Field Meter - E 180.1	Direct Reading Meter	Analyze immediately.	N/A	N/A	N/A

N/A = Not applicable.

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ATTACHMENT F

**FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS
PAGE 1 OF 3**

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.



**FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS**

Tetra Tech NUS, Inc.

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Project Site Name: _____				Sample ID No.: _____				
Project No.: _____				Sample Location: _____				
Sampled By: _____				Duplicate: <input type="checkbox"/>				
Field Analyst: _____				Blank: <input type="checkbox"/>				
Field Form Checked as per QA/QC Checklist (initials): _____								
SAMPLING DATA:								
Date: _____	Color (Visual)	pH (S.U.)	S.C. (mS/cm)	Temp. (°C)	Turbidity (NTU)	DO (mg/l)	Salinity (%)	ORP (Eh) (+/- mv)
Time: _____								
Method: _____								
SAMPLE COLLECTION/ANALYSIS INFORMATION:								
ORP (Eh) (+/- mv)				Electrode Make & Model: _____				
Reference Electrode (circle one): Silver-Silver Chloride / Calomel / Hydrogen								
Dissolved Oxygen:								
Equipment: Chemetrics Test Kit				Concentration: _____ ppm				
Range Used:	Range	Method	Concentration ppm	Analysis Time: _____				
<input type="checkbox"/>	0 to 1 ppm	K-7510						
<input type="checkbox"/>	1 to 12 ppm	K-7512						
Equipment: HACH Digital Titrator OX-DT				Analysis Time: _____				
Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration	
<input type="checkbox"/>	1-5 mg/L	200 ml	0.200 N	0.01	_____	x 0.01	= _____ mg/L	
<input type="checkbox"/>	2-10 mg/L	100 ml	0.200 N	0.02	_____	x 0.02	= _____ mg/L	
Notes: _____								
Carbon Dioxide:								
Equipment: Chemetrics Test Kit				Concentration: _____ ppm				
Range Used:	Range	Method	Concentration ppm	Analysis Time: _____				
<input type="checkbox"/>	10 to 100 ppm	K-1910						
<input type="checkbox"/>	100 to 1000 ppm	K-1920						
<input type="checkbox"/>	250 to 2500 ppm	K-1925						
Equipment: HACH Digital Titrator CA-DT				Analysis Time: _____				
Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration	
<input type="checkbox"/>	10-50 mg/L	200 ml	0.3636 N	0.1	_____	x 0.1	= _____ mg/L	
<input type="checkbox"/>	20-100 mg/L	100 ml	0.3636 N	0.2	_____	x 0.2	= _____ mg/L	
<input type="checkbox"/>	100-400 mg/L	200 ml	3.636 N	1.0	_____	x 1.0	= _____ mg/L	
<input type="checkbox"/>	200-1000 mg/L	100 ml	3.636 N	2.0	_____	x 2.0	= _____ mg/L	
Standard Additions: <input type="checkbox"/> Titrant Molarity: _____ Digits Required: 1st: _____ 2nd: _____ 3rd: _____								
Notes: _____								
Hydrogen, dissolved								
Equipment: Bubble strip sampling field method								
Start stripper at _____ (time)								
End stripper at _____ (time)								
Total stripper time _____								
Pump rate _____ milliliters/minute								

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**FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS
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Note: Analyte, method, and/or equipment may be deleted from form if not being performed.



**FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS**

Tetra Tech NUS, Inc.

Page of

Project Site Name: _____		Sample ID No.: _____					
Project No.: _____		Sample Location: _____					
Sampled By: _____		Duplicate: <input type="checkbox"/>					
Field Analyst: _____		Blank: <input type="checkbox"/>					
Alkalinity:							
Equipment: Chemetrics Test Kit		Concentration: _____ ppm					
Range Used:	Range	Method	Concentration ppm				
<input type="checkbox"/>	10 to 100 ppm	K-9810					
<input type="checkbox"/>	50 to 500 ppm	K-9815					
<input type="checkbox"/>	100 to 1000 ppm	K-9820					
		Analysis Time: _____					
Filtered: <input type="checkbox"/>							
Equipment: HACH Digital Titrator AL-DT							
Range Used:	Range	Sample Vol.	Cartridge	Multiplier	Titration Count	Multiplier	Concentration
<input type="checkbox"/>	10-40 mg/L	100 ml	0.1600 N	0.1	_____ & _____	x 0.1	= _____ mg/L
<input type="checkbox"/>	40-160 mg/L	25 ml	0.1600 N	0.4	_____ & _____	x 0.4	= _____ mg/L
<input type="checkbox"/>	100-400 mg/L	100 ml	1.600 N	1.0	_____ & _____	x 1.0	= _____ mg/L
<input type="checkbox"/>	200-800 mg/L	50 ml	1.600 N	2.0	_____ & _____	x 2.0	= _____ mg/L
<input type="checkbox"/>	500-2000 mg/L	20 ml	1.600 N	5.0	_____ & _____	x 5.0	= _____ mg/L
<input type="checkbox"/>	1000-4000 mg/L	10 ml	1.600 N	10.0	_____ & _____	x 10.0	= _____ mg/L
Parameter:		Hydroxide	Carbonate	Bicarbonate			
Relationship:							
Standard Additions: <input type="checkbox"/>		Titrant Molarity: _____		Digits Required: 1st.: _____ 2nd.: _____ 3rd.: _____			
Notes:							
Ferrous Iron (Fe²⁺):							
Equipment: DR-850		DR-8 __	Range: 0 - 3.00 mg/L		Concentration: _____ ppm		
Program/Module: 500nm		33			Analysis Time: _____		
Equipment: IR-18C Color Wheel		Range: 0 - 10 mg/L		Filtered: <input type="checkbox"/>			
Notes:							
Hydrogen Sulfide (H₂S):							
Equipment: HS-C		Other: _____		Range: 0 - 5 mg/L		Concentration: _____ ppm	
Exceeded 5.0 mg/L range on color chart: <input type="checkbox"/>				Analysis Time: _____			
Notes:							
Sulfide (S²⁻):							
Equipment: Chemetrics Test Kit		Range: 0 - 10 mg/L		Concentration: _____ ppm			
Range Used:	Range	Method	Concentration ppm				
<input type="checkbox"/>	0 to 1 ppm	K-9510					
<input type="checkbox"/>	1 to 10 ppm	K-9510					
		Analysis Time: _____		Filtered: <input type="checkbox"/>			
Equipment: DR-850		DR-8 __	Range: 0 - 0.70 mg/L				
Program/Module: 610nm		93					
Notes:							

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ATTACHMENT F

**FIELD ANALYTICAL LOG SHEET, GEOCHEMICAL PARAMETERS
PAGE 3 OF 3**

Note: Analyte, method, and/or equipment may be deleted from form if not being performed.



**FIELD ANALYTICAL LOG SHEET
GEOCHEMICAL PARAMETERS**

Tetra Tech NUS, Inc.

Page of

Project Site Name: _____		Sample ID No.: _____	
Project No.: _____		Sample Location: _____	
Sampled By: _____		Duplicate: <input type="checkbox"/>	
Field Analyst: _____		Blank: <input type="checkbox"/>	
Sulfate (SO₄²⁻):			
Equipment	DR-850	DR-8 __	Range: 0 - 70 mg/L
Concentration:	_____ ppm		
Program/Module:	_____ 91		
Analysis Time:	_____		
Standard Solution:	<input type="checkbox"/>	Results: _____	Filtered: <input type="checkbox"/>
Standard Additions:	<input type="checkbox"/>	Digits Required: 0.1ml: _____ 0.2ml: _____ 0.3ml: _____	
Notes: _____			
Nitrate (NO₃⁻-N):			
Equipment	DR-850	DR-8 __	Range: 0 - 0.50 mg/L ⁽¹⁾
Concentration:	_____ ppm		
Program/Module:	_____ 55		
Analysis Time:	_____		
Filtered:	<input type="checkbox"/>		
Standard Solution:	<input type="checkbox"/>	Results: _____	Nitrite Interference Treatment: <input type="checkbox"/>
Standard Additions:	<input type="checkbox"/>	Digits Required: 0.1ml: _____ 0.2ml: _____ 0.3ml: _____	Reagent Blank Correction: <input type="checkbox"/>
Alternate forms: NO ₂ _____ NaNO ₂ _____ mg/L			
Notes (1): If results are over limit use dilution method at step 3, 5ml sample 10ml DI result X3, range upto 1.5mg/L			
Notes: _____			
Nitrite (NO₂⁻-N):			
Equipment	DR-850	DR-8 __	Range: 0 - 0.350 mg/L
Concentration:	_____ ppm		
Program/Module:	_____ 62		
Analysis Time:	_____		
Filtered:	<input type="checkbox"/>		
Standard Solution:	<input type="checkbox"/>	Results: _____	Reagent Blank Correction: <input type="checkbox"/>
Notes: _____			
Manganese (Mn²⁺):			
Equipment	DR-850	DR-8 __	Range: 0 - 20.0 mg/L
Concentration:	_____ ppm		
Program/Module:	_____ 41		
Analysis Time:	_____		
Filtered:	<input type="checkbox"/>		
Standard Solution:	<input type="checkbox"/>	Results: _____	Digestion: <input type="checkbox"/>
Standard Additions:	<input type="checkbox"/>	Digits Required: 0.1ml: _____ 0.2ml: _____ 0.3ml: _____	Reagent Blank Correction: <input type="checkbox"/>
Notes: _____			
QA/QC Checklist:			
All data fields have been completed as necessary: <input type="checkbox"/>			
Correct measurement units are cited in the SAMPLING DATA block: <input type="checkbox"/>			
Values cited in the SAMPLING DATA block are consistent with the Groundwater Sample Log Sheet: <input type="checkbox"/>			
Multiplication is correct for each Multiplier table: <input type="checkbox"/>			
Final calculated concentration is within the appropriate Range Used block: <input type="checkbox"/>			
Alkalinity Relationship is determined appropriately as per manufacturer (HACH) instructions: <input type="checkbox"/>			
QA/QC sample (e.g., Std. Additions, etc.) frequency is appropriate as per the project planning documents: <input type="checkbox"/>			
Nitrite Interference treatment was used for Nitrate test if Nitrite was detected: <input type="checkbox"/>			
Title block on each page of form is initialized by person who performed this QA/QC Checklist: <input type="checkbox"/>			



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

Number	SA-2.5	Page	1 of 6
Effective Date	09/03	Revision	3
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>DS</i>		

Subject DIRECT PUSH TECHNOLOGY (GEOPROBE®/HYDROPUNCH™)

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1.0 PURPOSE

The purpose of this procedure is to provide general reference information on Direct Push Technology (DPT). DPT is designed to collect soil, groundwater, and soil gas samples without using conventional drilling techniques. The advantage of using DPT over conventional drilling includes the generation of little or no drill cuttings, sampling in locations with difficult accessibility, reduced overhead clearance requirements, no fluid introduction during probing, and typical lower costs per sample than with conventional techniques. Disadvantages include a maximum penetration depth of approximately 15 to 40 feet in dense soils (although it may be as much as 60 to 80 feet in certain types of geological environments), reduced capability of obtaining accurate water-level measurements, and the inability to install permanent groundwater monitoring wells. The methods and equipment described herein are for collection of surface and subsurface soil samples and groundwater samples. Soil gas sampling is discussed in SOP SA-2.4.

2.0 SCOPE

This procedure provides information on proper sampling equipment and techniques for DPT. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methodology.

3.0 GLOSSARY

Direct Push Technology (DPT) - DPT refers to sampling tools and sensors that are driven directly into the ground without the use of conventional drilling equipment. DPT typically utilizes hydraulic pressure and/or percussion hammers to advance the sampling tools. A primary advantage of DPT over conventional drilling techniques is that DPT results in the generation of little or no investigation derived waste.

Geoprobe® - Geoprobe® is a manufacturer of a hydraulically-powered, percussion/probing machines utilizing DPT to collect subsurface environmental samples. Geoprobe® relies on a relatively small amount of static weight (vehicle) combined with percussion as the energy for advancement of a tool string. The Geoprobe® equipment can be mounted in a multitude of vehicles for access to all types of environmental sites.

HydroPunch™ - HydroPunch™ is a manufacturer of stainless steel and Teflon® sampling tools that are capable of collecting representative groundwater and/or soil samples without requiring the installation of a groundwater monitoring well or conventional soil boring. HydroPunch™ is an example of DPT sampling equipment.

Flame Ionization Detector (FID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing a flame as the energizing source.

Photo Ionization Detector (PID) - A portable instrument for the measurement of many combustible organic compounds and a few inorganic compounds in air at parts-per million levels. The basis for the detection is the ionization of gaseous species utilizing ultraviolet radiation as the energizing source.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for selecting and/or reviewing the appropriate DPT drilling procedure required to support the project objectives.

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Field Operations Leader (FOL)- The FOL is primarily responsible for performing the DPT in accordance with the project-specific plan.

5.0 SOIL SAMPLING PROCEDURES

5.1 General

The common methodology for the investigation of the vadose zone is soil boring drilling and soil sampling. However, drilling soil borings can be very expensive. Generally the advantage of DPT for subsurface soil sampling is the reduced cost of disposal of drilling cuttings and shorter sampling times.

5.2 Sampling Equipment

Equipment needed for conducting DPT drilling for subsurface soil sampling includes, but is not limited to, the following:

- Geoprobe® Sampling Kit
- Cut-resistant gloves
- 4-foot x 1.5-inch diameter macrocore sampler
- Probe sampling adapters
- Roto-hammer with 1.5-inch bit
- Disposable acetate liners for soil macrocore sampler
- Cast aluminum or steel drive points
- Geoprobe® AT-660 Series Large Bore Soil Sampler, or equivalent
- Standard decontamination equipment and solutions

TD
4/27/11

For health and safety equipment and procedures, follow the direction provided in the Safe Work Permit in Attachment 1, or the more detailed directions provided in the project's Health and Safety Plan.

5.3 DPT Sampling Methodology

There are several methods for the collection of soil samples using DPT drilling. The most common method is discussed in the following section. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project-specific plan.

- Macrocore samplers fitted with detachable aluminum or steel drive points are driven into the ground using hydraulic pressure. If there is concrete or pavement over a sampling location, a Roto-hammer is used to drill a minimum 1.5-inch diameter hole through the surface material. A Roto-hammer may also be used if very dense soils are encountered.
- The sampler is advanced continuously in 4-foot intervals or less if desired. No soil cuttings are generated because the soil which is not collected in the sampler is displaced within the formation.
- The sampler is retracted from the hole, and the 4-foot continuous sample is removed from the outer coring tube. The sample is contained within an inner acetate liner.
- Attach the metal trough from the Geoprobe® Sampling Kit firmly to the tail gate of a vehicle. If a vehicle with a tail gate is not available, secure the trough on another suitable surface.
- Place the acetate liner containing the soils in the trough.

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- While wearing cut-resistant gloves (constructed of leather or other suitable material), cut the acetate liner through its entire length using the double-bladed ~~Ki~~ ^{4/27/99} knife that accompanies the Geoprobe® Sampling Kit. Then remove the strip of acetate from the trough to gain access to the collected soils. Do not attempt to cut the acetate liner while holding it in your hand.
- Field screen the sample with an FID or PID, and observe/examine the sample (according to SOP GH-1.3). If appropriate, transfer the sample to sample bottles for laboratory analysis. If additional volume is required, push an additional boring adjacent to the first and composite/mix the same interval. Field compositing is usually not acceptable for sample requiring volatile organics analysis.
- Once sampling has been completed, the hole is backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch is used to cap holes through paved or concrete areas. All holes should be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or a sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric operated equipment (e.g., jack hammer).
- Sampling equipment is decontaminated prior to collecting the next sample.

6.0 GROUNDWATER SAMPLING PROCEDURES

6.1 General

The most common methodology for the investigation of groundwater is the installation and sampling of permanent monitoring wells. If only groundwater screening is required, the installation and sampling of temporary well points may be performed. The advantage of temporary well point installation using DPT is reduced cost due to no or minimal disposal of drilling cuttings and well construction materials, and shorter installation/times sampling.

Two disadvantages of DPT drilling for well point installation are:

- In aquifers with low yields, well points may have to be sampled without purging or development.
- If volume requirements are high, this method can be time consuming for low yield aquifers.

6.2 Sampling Equipment

Equipment needed for temporary well installation and sampling using DPT includes, but is not limited, to the following:

- 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point
- Connecting rods
- Roto-hammer with 1.5-inch bit
- Mechanical jack
- 1/4-inch OD polyethylene tubing
- 3/8-inch OD polyethylene tubing
- Peristaltic pump
- Standard decontamination equipment and solutions

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6.3 DPT Temporary Well Point Installation and Sampling Methodology

There are several methods for the installation and sampling of temporary well points using DPT. The most common methodology is discussed below. Variations of the following method may be conducted upon approval of the Project Manager in accordance with the project specific plan.

- A 2-foot x 1-inch diameter mill-slotted (0.005 to 0.02-inch) well point attached to connecting rods is driven into the ground to the desired depth using a rotary electric hammer or other direct push drill rig. If there is concrete or pavement over a sampling location, a Roto-hammer or electric coring machine is used to drill a hole through the surface material.
- The well point will be allowed to equilibrate for at least 15 minutes, after which a measurement of the static water level will be taken. The initial measurement of the water level will be used to assess the amount of water which is present in the well point and to determine the amount of silt and sand infiltration that may have occurred.
- The well point will be developed using a peristaltic pump and polyethylene tubing to remove silt and sand which may have entered the well point. The well point is developed by inserting polyethylene tubing to the bottom of the well point and lifting and lowering the tubing slightly while the pump is operating. The pump will be operated at a maximum rate of approximately 2 liters per minute. After removal of sediment from the bottom of the well point, the well point will be vigorously pumped at maximum capacity until discharge water is visibly clear and no further sediments are being generated. Measurements of pH, specific conductance, temperature, and turbidity shall be recorded every 5 to 10 minutes during the purging process. After two consistent readings of pH, specific conductance, temperature and turbidity (± 10 percent), the well may be sampled.
- A sample will be collected using the peristaltic pump set at the same or reduced speed as during well development. Samples (with the exception of the samples to be analyzed for volatile organic compounds, VOCs) will be collected directly from the pump discharge. Sample containers for VOCs will be filled by (first shutting off the pump) crimping the discharge end of the sample tubing when filled, removing the inlet end of the sample tubing from the well, suspending the inlet tubing above the vial, and allowing water to fill each vial by gravity flow.
- Once the groundwater sample has been collected, the connecting rods and well point will be removed from the hole with the direct push rig hydraulics. The hole will be backfilled with bentonite chips or bentonite cement grout, depending upon project requirements. Asphalt or concrete patch will be used to cap holes through paved or concrete areas. All holes will be finished smooth to existing grade.
- In the event the direct push van/truck cannot be driven to a remote location or sampling location with difficult accessibility, sampling probes may be advanced and sampled manually or with air/electric-operated equipment (e.g., jack hammer).
- Decontaminate the equipment before moving to the next location.

7.0 RECORDS

A record of all field procedures, tests, and observations must be recorded in the field logbook, boring logs, and sample log sheets, as needed. Entries should include all pertinent data regarding the investigation. The use of sketches and field landmarks will help to supplement the investigation and evaluation.

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**ATTACHMENT 1
SAFE WORK PERMIT FOR DPT OPERATIONS**

Permit No. _____ Date: _____ Time: From _____ to _____

SECTION I: General Job Scope

- I. Work limited to the following (description, area, equipment used): Monitoring well drilling and installation through direct push technology
- II. Required Monitoring Instruments: _____
- III. Field Crew: _____
- IV. On-site Inspection conducted Yes No Initials of Inspector TtNUS

SECTION II: General Safety Requirements (To be filled in by permit issuer)

- V. Protective equipment required
 - Level D Level B
 - Level C Level A
 - Detailed on Reverse
- Respiratory equipment required
 - Full face APR
 - Half face APR
 - SKA-PAC SAR
 - Skid Rig
- Escape Pack
- SCBA
- Bottle Trailer
- None

Level D Minimum Requirements: Sleeved shirt and long pants, safety footwear, and work gloves. Safety glasses, hard hats, and hearing protection will be worn when working near or sampling in the vicinity of the DPT rig.

Modifications/Exceptions.

VI. Chemicals of Concern	Action Level(s)	Response Measures
_____	_____	_____

VII. Additional Safety Equipment/Procedures

- | | |
|---|--|
| Hard-hat <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Hearing Protection (Plugs/Muffs) <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Safety Glasses <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Safety belt/harness <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Chemical/splash goggles <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Radio <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No |
| Splash Shield <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No | Barricades <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No |
| Splash suits/coveralls <input type="checkbox"/> Yes <input type="checkbox"/> No | Gloves (Type - _____) <input type="checkbox"/> Yes <input type="checkbox"/> No |
| Steel toe Work shoes or boots <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No | Work/warming regimen <input type="checkbox"/> Yes <input type="checkbox"/> No |

Modifications/Exceptions: Reflective vests for high traffic areas.

VIII. Procedure review with permit acceptors	Yes	NA	Yes	NA
Safety shower/eyewash (Location & Use).....	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Daily tail gate meetings.....	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Contractor tools/equipment/PPE inspected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Emergency alarms	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Evacuation routes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Assembly points	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

IX. Site Preparation

- Utility Clearances obtained for areas of subsurface investigation Yes No
- Physical hazards removed or blockaded Yes No
- Site control boundaries demarcated/signage Yes No

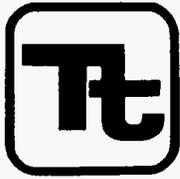
X. Equipment Preparation

- | | | |
|---|------------------------------|--|
| Equipment drained/depressurized | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> NA |
| Equipment purged/cleaned | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> NA |
| Isolation checklist completed | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> NA |
| Electrical lockout required/field switch tested | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> NA |
| Blinds/misalignments/blocks & bleeds in place | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> NA |
| Hazardous materials on walls/behind liners considered | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> NA |

- XI. Additional Permits required (Hot work, confined space entry). Yes No
If yes, complete permit required or contact Health Sciences, Pittsburgh Office

XII. Special instructions, precautions:

Permit Issued by: _____ Permit Accepted by: _____



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Effective Date	02/04	Revision	3
Applicability	Tetra Tech NUS, Inc.		
Prepared	Earth Sciences Department		
Approved	D. Senovich <i>[Signature]</i>		

Subject
NON-RADIOLOGICAL SAMPLE HANDLING

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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 (y261.30 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 (y261.20 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 - H₂SO₄
- Nitric Acid - HNO₃
- Sodium Hydroxide - NaOH

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Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - Na₂S₂O₃

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

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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 HNO₃, 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 ₂ SO ₄)	1 part concentrated H ₂ SO 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:

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- 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).

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- 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.

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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.

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ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
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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/Inorga nic	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
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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.

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ATTACHMENT B

**ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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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 ₂ SO 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 ₂ SO 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 ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H ₂ SO 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 ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H ₂ SO 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

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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

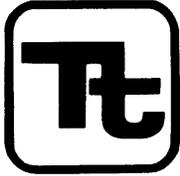
ORGANIC TESTS:⁽⁸⁾

Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days
Phenols ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Benzidines ^{(11), (12)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction

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ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
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- (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-diphenylhydrazine 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% Na₂S₂O₃ 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% Na₂S₂O₃.



TETRA TECH NUS, INC.

STANDARD OPERATING PROCEDURES

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Prepared	Earth Sciences Department		
Approved	Tom Johnston <i>T.E. Johnston</i>		

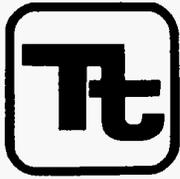
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FIELD DOCUMENTATION

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NON-RADIOLOGICAL SAMPLE HANDLING

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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 (y261.30 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 (y261.20 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 - H₂SO₄
- Nitric Acid - HNO₃
- Sodium Hydroxide - NaOH

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Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - Na₂S₂O₃

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

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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 HNO₃, 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 ₂ SO ₄)	1 part concentrated H ₂ SO 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:

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- 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).

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- 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.

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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.

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ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration	Container ⁽¹⁾	Sample Size	Preservation ⁽²⁾	Holding Time ⁽²⁾
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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/Inorga nic	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
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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.

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ATTACHMENT B

**ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
AND HOLDING TIMES**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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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 ₂ SO 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 ₂ SO 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 ₂ SO ₄ to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H ₂ SO ₄ to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H ₂ SO 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 ₂ SO ₄ to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H ₂ SO 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

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ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES,
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PAGE TWO**

Parameter Number/Name	Container ⁽¹⁾	Preservation ⁽²⁾⁽³⁾	Maximum Holding Time ⁽⁴⁾
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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 ₂ S ₂ O ₃ ⁽⁵⁾	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ HCl to pH 2 ⁽⁹⁾	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾ adjust pH to 4-5 ⁽¹⁰⁾	14 days
Phenols ⁽¹¹⁾	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction
Benzidines ^{(11), (12)}	G, Teflon-lined cap	Cool, 4°C; 0.008% Na ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O 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 ₂ S ₂ O ₃ ⁽⁵⁾	7 days until extraction; 40 days after extraction

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- (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-diphenylhydrazine 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% Na₂S₂O₃ 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% Na₂S₂O₃.

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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

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- 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

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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

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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.

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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.

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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

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- 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

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**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 jenny 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 manager 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

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**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:	

Subject

FIELD DOCUMENTATION

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3

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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		CITY, STATE	
STANDARD TAT <input type="checkbox"/>		RUSH TAT <input type="checkbox"/>		CARRIER/WAYBILL NUMBER		CONTAINER TYPE		PLASTIC (P) or GLASS (G)	
<input type="checkbox"/> 24 hr. <input type="checkbox"/> 48 hr. <input type="checkbox"/> 72 hr. <input type="checkbox"/> 14 day		LOCATION ID		MATRIX (GW, SO, SW, SD, QC, ETC.)		PRESERVATIVE USED		NO. OF CONTAINERS	
DATE	YEAR	TIME	SAMPLE ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	COLLECTION METHOD	GRAP (G)	COMP (C)	<p style="writing-mode: vertical-rl; transform: rotate(180deg);">TYPE OF MESS</p> <p style="writing-mode: vertical-rl; transform: rotate(180deg);">COMMENTS</p>
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. TINUS-001

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**ATTACHMENT D
CHAIN-OF-CUSTODY SEAL**

<u>Signature</u> <hr/> <u>Date</u> <hr/> CUSTODY SEAL		CUSTODY SEAL <hr/> <u>Date</u> <hr/> <u>Signature</u>
--	--	--



STANDARD OPERATING PROCEDURES

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Effective Date 01/28/2009	Revision 6
Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved Tom Johnston <i>T.E. Johnston</i>	

Subject DECONTAMINATION OF FIELD EQUIPMENT

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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.

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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).

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- 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

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- 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.

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- 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.

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- 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.

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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.

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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).

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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.

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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. TD
4/27/11
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.

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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.

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- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

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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

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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.



STANDARD OPERATING PROCEDURES

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Applicability Tetra Tech NUS, Inc.	
Prepared Earth Sciences Department	
Approved Tom Johnston <i>T.E. Johnston</i>	

Subject DECONTAMINATION OF FIELD EQUIPMENT

Attachment A iDW Label

INVESTIGATION DERIVED WASTE

GENERATOR INFORMATION:

SITE _____ JOB NO. _____

LOCATION _____

DATE _____

DRUM# _____

CONTENTS _____

VOLUME _____

CONTACT _____

EMERGENCY PHONE NUMBER _____

APPENDIX C

**NAVAL CONSTRUCTION BATTALION CENTER
EXCAVATION PERMIT**

**NAVAL CONSTRUCTION BATTALION CENTER
EXCAVATION PERMIT**
Public Works Department
(228) 871-2244 Fax (228) 871-3384

Date of Request: _____ Planned Start Date: _____

Location: _____

Description of Work: _____

**Mississippi One Control Number: _____

Name of Company / Department: _____

Address: _____

Company Point of Contact: _____ Phone: _____

PWD Engineering Tech: _____ Phone: _____

Utility	Verified	Marked	Dig	COMMENTS
IR Site (Environmental)				
Electrical (PWD)				
Water (PWD)				
Sanitary Sewer (PWD)				
Storm Drain (PWD)				
Miscellaneous Utilities (PWD)				
Telephone-Navy (CBC Comm)				
Fiber Optic (CBC Comm)				
Gas (MS One)				
Cable TV (MS One)				
Telephone- AT&T/ Sprint (MS One)				

READ PRIOR TO SUBMISSION OF REQUEST:

- Planned Start Date must be at least 2 weeks after date of submission.
- Locates will be marked within 10 working days of receiving required information from requester.
- Locates are valid for 10 days; renewals are required thereafter.
- Locates under the control of the requester, "within limits of construction" are valid throughout the construction project.
- Requestor is responsible for initiating required renewal.
- No excavation will begin without a valid dig permit for site.

REQUESTER MUST COMPLETE THE FOLLOWING PRIOR TO SUBMISSION OF DIG PERMIT REQUEST:

- Mississippi One Control number. (Available by calling (800) 227-6477, (601) 362-4374, or 811)
- Submit base map of work site area with excavation details clearly marked. (Required paper size is 8 1/2 x 11).
- Requestor will submit with digging permit request, a copy of the Mississippi one permit request.
- Requested excavation site must be white-lined. (Permits will be returned if site is unmarked)

PWD, Production Division Director / Date

APPENDIX D
ANALYTICAL LABORATORY
DOD ELAP ACCREDITATION DOCUMENTS

Scope of Accreditation For Empirical Laboratories, LLC

621 Mainstream Drive, Suite 270
Nashville, TN 37228
Marcia K. McGinnity
1-877-345-1113

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.1) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Empirical Laboratories, LLC to perform the following tests:

Accreditation granted through: **November 30, 2012**

Testing - Environmental

Non-Potable Water		
Technology	Method	Analyte
GC/MS	8260B	1,1,1-Trichloroethane (1,1,1-TCA)
GC/MS	8260B	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)
GC/MS	8260B	1,1,2-Trichloroethane
GC/MS	8260B	1,1,2,2-Tetrachloroethane
GC/MS	8260B	1,1,1,2-Tetrachloroethane
GC/MS	8260B	1,1-Dichloroethane (1,1-DCA)
GC/MS	8260B	1,1-Dichloroethene (1,1-DCE)
GC/MS	8260B	1,2,3-Trichlorobenzene
GC/MS	8260B	1,2,4-Trichlorobenzene
GC/MS	8260B	1,2,3-Trichloropropane
GC/MS	8260B	1,2,4-Trimethylbenzene
GC/MS	8260B	1,3,5-Trimethylbenzene
GC/MS	8260B	1,2-Dibromoethane (EDB)
GC/MS	8260B	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	8260B	1,2-Dichlorobenzene
GC/MS	8260B	1,2-Dichloroethane (EDC)
GC/MS	8260B	1,2-Dichloropropane
GC/MS	8260B	1,3-Dichlorobenzene

Non-Potable Water		
Technology	Method	Analyte
GC/MS	8260B	1,4-Dichlorobenzene
GC/MS	8260B	1,1-Dichloropropene
GC/MS	8260B	1,3-Dichloropropane
GC/MS	8260B	2,2-Dichloropropane
GC/MS	8260B	2-Butanone (Methyl ethyl ketone; MEK)
GC/MS	8260B	2-Hexanone (Methyl butyl ketone; MBK)
GC/MS	8260B	4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)
GC/MS	8260B	Acetone
GC/MS	8260B	Benzene
GC/MS	8260B	Bromochloromethane
GC/MS	8260B	Bromodichloromethane
GC/MS	8260B	Bromobenzene
GC/MS	8260B	Bromoform
GC/MS	8260B	Bromomethane
GC/MS	8260B	n-Butylbenzene
GC/MS	8260B	sec-Butylbenzene
GC/MS	8260B	tert-Butylbenzene
GC/MS	8260B	Carbon Disulfide
GC/MS	8260B	Carbon Tetrachloride
GC/MS	8260B	Chlorobenzene
GC/MS	8260B	Chloroethane
GC/MS	8260B	Chloroform
GC/MS	8260B	Chloromethane
GC/MS	8260B	2-Chlorotoluene
GC/MS	8260B	4-Chlorotoluene
GC/MS	8260B	cis-1,2-Dichloroethene (cis-1,2-DCE)
GC/MS	8260B	cis-1,3-Dichloropropene
GC/MS	8260B	Cyclohexane
GC/MS	8260B	Dibromochloromethane
GC/MS	8260B	Dibromomethane
GC/MS	8260B	Dichlorodifluoromethane (CFC-12)
GC/MS	8260B	Ethylbenzene
GC/MS	8260B	Hexachlorobutadiene
GC/MS	8260B	Isopropylbenzene (Cumene)
GC/MS	8260B	p-Isopropyltoluene
GC/MS	8260B	Methyl Acetate
GC/MS	8260B	Methyl Tertiary Butyl Ether (MTBE)
GC/MS	8260B	Methylcyclohexane
GC/MS	8260B	Methylene Chloride, or Dichloromethane

Non-Potable Water		
Technology	Method	Analyte
GC/MS	8260B	Naphthalene
GC/MS	8260B	n-Propylbenzene
GC/MS	8260B	Styrene
GC/MS	8260B	Tetrachloroethene (PCE; PERC)
GC/MS	8260B	Toluene
GC/MS	8260B	trans-1,2-Dichloroethene (trans-1,2-DCE)
GC/MS	8260B	trans-1,3-Dichloropropene
GC/MS	8260B	Trichloroethene (TCE)
GC/MS	8260B	Trichlorofluoromethane (CFC-11)
GC/MS	8260B	Vinyl Chloride (VC)
GC/MS	8260B	Xylenes (Total)
GC/MS	8260B	Acrolein
GC/MS	8260B	Acrylonitrile
GC/MS	8260B	Di-isopropyl ether
GC/MS	8260B	ETBE
GC/MS	8260B	Ethyl methacrylate
GC/MS	8260B	Iodomethane
GC/MS	8260B	Methyl methacrylate
GC/MS	8260B	t-Butyl alcohol
GC/MS	8260B	tert-Amyl methyl ether
GC/MS	8260B	Vinyl acetate
GC/MS	8270C/D	Bis(2-chloroisopropyl)ether, or 2,2'-oxybis (1-Chloropropane)
GC/MS	8270C/D	1,2-Dichlorobenzene
GC/MS	8270C/D	1,3-Dichlorobenzene
GC/MS	8270C/D	1,4-Dichlorobenzene
GC/MS	8270C/D	2,4,5-Trichlorophenol
GC/MS	8270C/D	2,4,6-Trichlorophenol (TCP)
GC/MS	8270C/D	2,4-Dichlorophenol (DCP)
GC/MS	8270C/D	2,4-Dimethylphenol
GC/MS	8270C/D	2,4-Dinitrophenol
GC/MS	8270C/D	2,4-Dinitrotoluene (DNT)
GC/MS	8270C/D	2,6-Dichlorophenol
GC/MS	8270C/D	2,6-Dinitrotoluene
GC/MS	8270C/D	1,2-Diphenylhydrazine
GC/MS	8270C/D	2-Chloronaphthalene
GC/MS	8270C/D	2-Chlorophenol
GC/MS	8270C/D	2-Methylnaphthalene
GC/MS	8270C/D	2-Methylphenol (o-Cresol)
GC/MS	8270C/D	2-Nitroaniline

Non-Potable Water		
Technology	Method	Analyte
GC/MS	8270C/D	2-Nitrophenol (ONP)
GC/MS	8270C/D	3,3'-Dichlorobenzidine (DCB)
GC/MS	8270C/D	3-Methylphenol
GC/MS	8270C/D	3-Nitroaniline
GC/MS	8270C/D	4,6-Dinitro-2-methylphenol (DNOC)
GC/MS	8270C/D	4-Bromophenyl phenyl ether
GC/MS	8270C/D	4-Chloro-3-methylphenol
GC/MS	8270C/D	4-Chloroaniline
GC/MS	8270C/D	4-Chlorophenyl phenyl ether
GC/MS	8270C/D	4-Methylphenol (p-Cresol)
GC/MS	8270C/D	4-Nitroaniline (PNA)
GC/MS	8270C/D	4-Nitrophenol (PNP)
GC/MS	8270C/D	Acenaphthene
GC/MS	8270C/D	Acenaphthylene
GC/MS	8270C/D	Acetaphenone
GC/MS	8270C/D	Anthracene
GC/MS	8270C/D	Benzo(a)anthracene
GC/MS	8270C/D	Benzo(a)pyrene
GC/MS	8270C/D	Benzo(b)fluoranthene
GC/MS	8270C/D	Benzo(g,h,i)perylene
GC/MS	8270C/D	Benzo(k)fluoranthene
GC/MS	8270C/D	Benzyl alcohol
GC/MS	8270C/D	Benzoic Acid
GC/MS	8270C/D	bis(2-Chloroethoxy)methane
GC/MS	8270C/D	bis(2-Chloroethyl)ether (BCEE)
GC/MS	8270C/D	bis(2-Ethylhexyl)phthalate (BEHP)
GC/MS	8270C/D	Butyl benzyl phthalate (BBP)
GC/MS	8270C/D	Carbazole
GC/MS	8270C/D	Chrysene
GC/MS	8270C/D	Di-n-butyl phthalate (DBP)
GC/MS	8270C/D	Di-n-octyl phthalate (DNOP)
GC/MS	8270C/D	Dibenz(a,h)anthracene
GC/MS	8270C/D	Dibenzofuran (DBF)
GC/MS	8270C/D	Diethyl phthalate (DEP)
GC/MS	8270C/D	Dimethyl phthalate (DMP)
GC/MS	8270C/D	Fluoranthene
GC/MS	8270C/D	Fluorene
GC/MS	8270C/D	Hexachlorobenzene (HCB)
GC/MS	8270C/D	Hexachlorobutadiene (HCBD)

Non-Potable Water		
Technology	Method	Analyte
GC/MS	8270C/D	Hexachlorocyclopentadiene (HCCPD)
GC/MS	8270C/D	Hexachloroethane (HCE)
GC/MS	8270C/D	Indeno(1,2,3-cd)pyrene
GC/MS	8270C/D	Isophorone
GC/MS	8270C/D	N-Nitrosodimethylamine
GC/MS	8270C/D	N-Nitroso-di-n-propylamine (NDPA)
GC/MS	8270C/D	N-nitrosodiphenylamine (NDPHA)
GC/MS	8270C/D	Naphthalene
GC/MS	8270C/D	Nitrobenzene
GC/MS	8270C/D	Pentachlorophenol
GC/MS	8270C/D	Phenanthrene
GC/MS	8270C/D	Phenol
GC/MS	8270C/D	Pyrene
GC/MS	8270C/D	Pyridine
GC/MS	8270C/D	1,2,4-Trichlorobenzene
GC/MS	8270C/D	1,1'-Biphenyl
GC/MS	8270C/D	1,2,4,5-Tetrachlorobenzene
GC/MS	8270C/D	1,4-Dioxane
GC/MS	8270C/D	1-Methylnaphthalene
GC/MS	8270C/D	2,3,4,6-Tetrachlorophenol
GC/MS	8270C/D	Aniline
GC/MS	8270C/D	Atrazine
GC/MS	8270C/D	Benzaldehyde
GC/MS	8270C/D	Benzidine
GC/MS	8270C/D	Caprolactam
GC/ECD	8081A/B	4,4'-DDD
GC/ECD	8081A/B	4,4'-DDE
GC/ECD	8081A/B	4,4'-DDT
GC/ECD	8081A/B	Aldrin
GC/ECD	8081A/B	alpha-BHC (alpha-HCH)
GC/ECD	8081A/B	alpha-Chlordane
GC/ECD	8081A/B	beta-BHC (beta-HCH)
GC/ECD	8081A/B	delta-BHC (delta-HCH)
GC/ECD	8081A/B	Dieldrin
GC/ECD	8081A/B	Endosulfan I
GC/ECD	8081A/B	Endosulfan II
GC/ECD	8081A/B	Endosulfan sulfate
GC/ECD	8081A/B	Endrin

Non-Potable Water		
Technology	Method	Analyte
GC/ECD	8081A/B	Endrin aldehyde
GC/ECD	8081A/B	Endrin ketone
GC/ECD	8081A/B	gamma-BHC (Lindane; gamma-HCH)
GC/ECD	8081A/B	gamma-Chlordane
GC/ECD	8081A/B	Heptachlor
GC/ECD	8081A/B	Heptachlor epoxide
GC/ECD	8081A/B	Methoxychlor
GC/ECD	8081A/B	Chlordane
GC/ECD	8081A/B	Toxaphene
GC/ECD	8082 /A	Aroclor-1016
GC/ECD	8082 /A	Aroclor-1221
GC/ECD	8082 /A	Aroclor-1232
GC/ECD	8082 /A	Aroclor-1242
GC/ECD	8082 /A	Aroclor-1248
GC/ECD	8082 /A	Aroclor-1254
GC/ECD	8082 /A	Aroclor-1260
GC/ECD	8151A	2,4,5-T
GC/ECD	8151A	2,4,5-TP (Silvex)
GC/ECD	8151A	2,4-D
GC/ECD	8151A	2,4-DB
GC/ECD	8151A	Dalapon
GC/ECD	8151A	Dicamba
GC/ECD	8151A	Dichlorprop
GC/ECD	8151A	Dinoseb
GC/ECD	8151A	MCPA
GC/ECD	8151A	MCPP (Mecoprop)
HPLC/UV	8330A	1,3,5-Trinitrobenzene
HPLC/UV	8330A	1,3-Dinitrobenzene
HPLC/UV	8330A	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	8330A	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	8330A	2,4-Dinitrotoluene (DNT)
HPLC/UV	8330A	2,6-Dinitrotoluene
HPLC/UV	8330A	2-Amino-4,6-dinitrotoluene
HPLC/UV	8330A	2-Nitrotoluene (ONT)
HPLC/UV	8330A	3-Nitrotoluene
HPLC/UV	8330A	4-Amino-2,6-dinitrotoluene
HPLC/UV	8330A	4-Nitrotoluene (PNT)
HPLC/UV	8330A	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	8330A	Nitroglycerin

Non-Potable Water		
Technology	Method	Analyte
HPLC/UV	8330A	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	8330A	3,5-Dinitroaniline
HPLC/UV	8330A	PETN
GC/FID	8015B	TPH DRO
GC/FID	8015B	TPH GRO
GC/FID	RSK-175	Methane
GC/FID	RSK-175	Ethane
GC/FID	RSK-175	Ethene
GC/ECD	8011	1,2-Dibromoethane (EDB)
GC/ECD	8011	1,2-Dibromo-3-chloropropane (DBCP)
HPLC/MS	6850	Perchlorate
ICP	6010B/C	Aluminum
ICP	6010B/C	Antimony
ICP	6010B/C	Arsenic
ICP	6010B/C	Barium
ICP	6010B/C	Beryllium
ICP	6010B/C	Cadmium
ICP	6010B/C	Calcium
ICP	6010B/C	Chromium, total
ICP	6010B/C	Cobalt
ICP	6010B/C	Copper
ICP	6010B/C	Iron
ICP	6010B/C	Lead
ICP	6010B/C	Magnesium
ICP	6010B/C	Manganese
CVAA	7470A	Mercury
ICP	6010B/C	Nickel
ICP	6010B/C	Potassium
ICP	6010B/C	Selenium
ICP	6010B/C	Silver
ICP	6010B/C	Sodium
ICP	6010B/C	Thallium
ICP	6010B/C	Vanadium
ICP	6010B/C	Zinc
ICP	6010B/C	Molybdenum
ICP	6010B/C	Tin
ICP	6010B/C	Titanium
IC	300.0	Chloride
IC	300.0	Fluoride

Non-Potable Water		
Technology	Method	Analyte
IC	300.0	Nitrate
IC	300.0	Nitrite
IC	300.0	Sulfate
IC	9056A	Chloride
IC	9056A	Fluoride
IC	9056A	Nitrate
IC	9056A	Nitrite
IC	9056A	Sulfate
Titration	SM 2320B 20th ed.	Alkalinity
ISE	SM 4500 B, D, 20th ed.	Ammonia
UV/Vis	7196A	Hexavalent Chromium
Colorimetric	353.2	Nitrate/Nitrite
Titration	Chap.7, Sect. 7.3.4 Mod.	Reactive Sulfide
Titration	SM 4500 S-2CF, 20th edition	Sulfide
UV/Vis	SM 4500 P B5, E, 20th edition	Total Phosphorus
UV/Vis	SM 4500 PE, 20th edition	Ortho-Phosphorus
TOC	9060A/SM5310C, 20 th edition	Total Organic Carbon
Gravimetric	SM 2540C, 20th edition	TDS
Colorimetric	9012A/B	Cyanide
Physical	1010A	Ignitability
Physical	9095B	Paint Filter
Probe	9040B/C	pH
Preparation	Method	Type
Preparation	1311	TCLP
Preparation	3005A	Metals digestion
Preparation	3010A	Metals digestion
Preparation	3510C	Organics Liquid Extraction
Preparation	5030A/B	Purge and Trap Water

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	8260B	1,1,1-Trichloroethane (1,1,1-TCA)
GC/MS	8260B	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)
GC/MS	8260B	1,1,2-Trichloroethane
GC/MS	8260B	1,1,2,2-Tetrachloroethane
GC/MS	8260B	1,1,1,2-Tetrachloroethane
GC/MS	8260B	1,1-Dichloroethane (1,1-DCA)
GC/MS	8260B	1,1-Dichloroethene (1,1-DCE)
GC/MS	8260B	1,2,3-Trichlorobenzene
GC/MS	8260B	1,2,4-Trichlorobenzene
GC/MS	8260B	1,2,3-Trichloropropane
GC/MS	8260B	1,2,4-Trimethylbenzene
GC/MS	8260B	1,3,5-Trimethylbenzene
GC/MS	8260B	1,2-Dibromoethane (EDB)
GC/MS	8260B	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	8260B	1,2-Dichlorobenzene
GC/MS	8260B	1,2-Dichloroethane (EDC)
GC/MS	8260B	1,2-Dichloropropane
GC/MS	8260B	1,3-Dichlorobenzene
GC/MS	8260B	1,4-Dichlorobenzene
GC/MS	8260B	1,1-Dichloropropene
GC/MS	8260B	1,3-Dichloropropane
GC/MS	8260B	2,2-Dichloropropane
GC/MS	8260B	2-Butanone (Methyl ethyl ketone; MEK)
GC/MS	8260B	2-Hexanone (Methyl butyl ketone; MBK)
GC/MS	8260B	4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)
GC/MS	8260B	Acetone
GC/MS	8260B	Benzene
GC/MS	8260B	Bromochloromethane
GC/MS	8260B	Bromodichloromethane
GC/MS	8260B	Bromobenzene
GC/MS	8260B	Bromoform
GC/MS	8260B	Bromomethane
GC/MS	8260B	n-Butylbenzene
GC/MS	8260B	sec-Butylbenzene
GC/MS	8260B	tert-Butylbenzene
GC/MS	8260B	Carbon Disulfide
GC/MS	8260B	Carbon Tetrachloride
GC/MS	8260B	Chlorobenzene
GC/MS	8260B	Chloroethane

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	8260B	Chloroform
GC/MS	8260B	Chloromethane
GC/MS	8260B	2-Chlorotoluene
GC/MS	8260B	4-Chlorotoluene
GC/MS	8260B	cis-1,2-Dichloroethene (cis-1,2-DCE)
GC/MS	8260B	cis-1,3-Dichloropropene
GC/MS	8260B	Cyclohexane
GC/MS	8260B	Dibromochloromethane
GC/MS	8260B	Dibromomethane
GC/MS	8260B	Dichlorodifluoromethane (CFC-12)
GC/MS	8260B	Ethylbenzene
GC/MS	8260B	Hexachlorobutadiene
GC/MS	8260B	Isopropylbenzene (Cumene)
GC/MS	8260B	p-Isopropyltoluene
GC/MS	8260B	Methyl Acetate
GC/MS	8260B	Methyl Tertiary Butyl Ether (MTBE)
GC/MS	8260B	Methylcyclohexane
GC/MS	8260B	Methylene Chloride, or Dichloromethane
GC/MS	8260B	Naphthalene
GC/MS	8260B	n-Propylbenzene
GC/MS	8260B	Styrene
GC/MS	8260B	Tetrachloroethene (PCE; PERC)
GC/MS	8260B	Toluene
GC/MS	8260B	trans-1,2-Dichloroethene (trans-1,2-DCE)
GC/MS	8260B	trans-1,3-Dichloropropene
GC/MS	8260B	Trichloroethene (TCE)
GC/MS	8260B	Trichlorofluoromethane (CFC-11)
GC/MS	8260B	Vinyl Chloride (VC)
GC/MS	8260B	Xylenes (Total)
GC/MS	8260B	Acrolein
GC/MS	8260B	Acrylonitrile
GC/MS	8260B	Ethyl methacrylate
GC/MS	8260B	Iodomethane
GC/MS	8260B	Methyl methacrylate
GC/MS	8260B	Vinyl acetate
GC/MS	8270C/D	Bis(2-chloroisopropyl)ether, or 2,2'-oxybis (1-Chloropropane)
GC/MS	8270C/D	1,2-Dichlorobenzene
GC/MS	8270C/D	1,3-Dichlorobenzene
GC/MS	8270C/D	1,4-Dichlorobenzene

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	8270C/D	2,4,5-Trichlorophenol
GC/MS	8270C/D	2,4,6-Trichlorophenol (TCP)
GC/MS	8270C/D	2,4-Dichlorophenol (DCP)
GC/MS	8270C/D	2,4-Dimethylphenol
GC/MS	8270C/D	2,4-Dinitrophenol
GC/MS	8270C/D	2,4-Dinitrotoluene (DNT)
GC/MS	8270C/D	2,6-Dichlorophenol
GC/MS	8270C/D	2,6-Dinitrotoluene
GC/MS	8270C/D	1,2-Diphenylhydrazine
GC/MS	8270C/D	2-Chloronaphthalene
GC/MS	8270C/D	2-Chlorophenol
GC/MS	8270C/D	2-Methylnaphthalene
GC/MS	8270C/D	2-Methylphenol (o-Cresol)
GC/MS	8270C/D	2-Nitroaniline
GC/MS	8270C/D	2-Nitrophenol (ONP)
GC/MS	8270C/D	3,3'-Dichlorobenzidine (DCB)
GC/MS	8270C/D	3-Methylphenol
GC/MS	8270C/D	3-Nitroaniline
GC/MS	8270C/D	4,6-Dinitro-2-methylphenol (DNOC)
GC/MS	8270C/D	4-Bromophenyl phenyl ether
GC/MS	8270C/D	4-Chloro-3-methylphenol
GC/MS	8270C/D	4-Chloroaniline
GC/MS	8270C/D	4-Chlorophenyl phenyl ether
GC/MS	8270C/D	4-Methylphenol (p-Cresol)
GC/MS	8270C/D	4-Nitroaniline (PNA)
GC/MS	8270C/D	4-Nitrophenol (PNP)
GC/MS	8270C/D	Acenaphthene
GC/MS	8270C/D	Acenaphthylene
GC/MS	8270C/D	Acetaphenone
GC/MS	8270C/D	Anthracene
GC/MS	8270C/D	Benzo(a)anthracene
GC/MS	8270C/D	Benzo(a)pyrene
GC/MS	8270C/D	Benzo(b)fluoranthene
GC/MS	8270C/D	Benzo(g,h,i)perylene
GC/MS	8270C/D	Benzo(k)fluoranthene
GC/MS	8270C/D	Benzyl alcohol
GC/MS	8270C/D	Benzoic Acid
GC/MS	8270C/D	bis(2-Chloroethoxy)methane
GC/MS	8270C/D	bis(2-Chloroethyl)ether (BCEE)

Solid and Chemical Materials		
Technology	Method	Analyte
GC/MS	8270C/D	bis(2-Ethylhexyl)phthalate (BEHP)
GC/MS	8270C/D	Butyl benzyl phthalate (BBP)
GC/MS	8270C/D	Carbazole
GC/MS	8270C/D	Chrysene
GC/MS	8270C/D	Di-n-butyl phthalate (DBP)
GC/MS	8270C/D	Di-n-octyl phthalate (DNOP)
GC/MS	8270C/D	Dibenz(a,h)anthracene
GC/MS	8270C/D	Dibenzofuran (DBF)
GC/MS	8270C/D	Diethyl phthalate (DEP)
GC/MS	8270C/D	Dimethyl phthalate (DMP)
GC/MS	8270C/D	Fluoranthene
GC/MS	8270C/D	Fluorene
GC/MS	8270C/D	Hexachlorobenzene (HCB)
GC/MS	8270C/D	Hexachlorobutadiene (HCBd)
GC/MS	8270C/D	Hexachlorocyclopentadiene (HCCPD)
GC/MS	8270C/D	Hexachloroethane (HCE)
GC/MS	8270C/D	Indeno(1,2,3-cd)pyrene
GC/MS	8270C/D	Isophorone
GC/MS	8270C/D	N-Nitrosodimethylamine
GC/MS	8270C/D	N-Nitroso-di-n-propylamine (NDPA)
GC/MS	8270C/D	N-nitrosodiphenylamine (NDPHA)
GC/MS	8270C/D	Naphthalene
GC/MS	8270C/D	Nitrobenzene
GC/MS	8270C/D	Pentachlorophenol
GC/MS	8270C/D	Phenanthrene
GC/MS	8270C/D	Phenol
GC/MS	8270C/D	Pyrene
GC/MS	8270C/D	Pyridine
GC/MS	8270C/D	1,2,4-Trichlorobenzene
GC/MS	8270C/D	1,1'-Biphenyl
GC/MS	8270C/D	1,2,4,5-Tetrachlorobenzene
GC/MS	8270C/D	1,4-Dioxane
GC/MS	8270C/D	1-Methylnaphthalene
GC/MS	8270C/D	2,3,4,6-Tetrachlorophenol
GC/MS	8270C/D	Aniline
GC/MS	8270C/D	Atrazine
GC/MS	8270C/D	Benzaldehyde
GC/MS	8270C/D	Benzidine
GC/MS	8270C/D	Caprolactam

Solid and Chemical Materials		
Technology	Method	Analyte
GC/ECD	8081A/B	4,4'-DDD
GC/ECD	8081A/B	4,4'-DDE
GC/ECD	8081A/B	4,4'-DDT
GC/ECD	8081A/B	Aldrin
GC/ECD	8081A/B	alpha-BHC (alpha-HCH)
GC/ECD	8081A/B	alpha-Chlordane
GC/ECD	8081A/B	beta-BHC (beta-HCH)
GC/ECD	8081A/B	delta-BHC (delta-HCH)
GC/ECD	8081A/B	Dieldrin
GC/ECD	8081A/B	Endosulfan I
GC/ECD	8081A/B	Endosulfan II
GC/ECD	8081A/B	Endosulfan sulfate
GC/ECD	8081A/B	Endrin
GC/ECD	8081A/B	Endrin aldehyde
GC/ECD	8081A/B	Endrin ketone
GC/ECD	8081A/B	gamma-BHC (Lindane; gamma-HCH)
GC/ECD	8081A/B	gamma-Chlordane
GC/ECD	8081A/B	Heptachlor
GC/ECD	8081A/B	Heptachlor epoxide
GC/ECD	8081A/B	Methoxychlor
GC/ECD	8081A/B	Chlordane
GC/ECD	8081A/B	Toxaphene
GC/ECD	8082 /A	Aroclor-1016
GC/ECD	8082 /A	Aroclor-1221
GC/ECD	8082 /A	Aroclor-1232
GC/ECD	8082 /A	Aroclor-1242
GC/ECD	8082 /A	Aroclor-1248
GC/ECD	8082 /A	Aroclor-1254
GC/ECD	8082 /A	Aroclor-1260
GC/ECD	8151A	2,4,5-T
GC/ECD	8151A	2,4,5-TP (Silvex)
GC/ECD	8151A	2,4-D
GC/ECD	8151A	2,4-DB
GC/ECD	8151A	Dalapon
GC/ECD	8151A	Dicamba
GC/ECD	8151A	Dichlorprop
GC/ECD	8151A	Dinoseb
GC/ECD	8151A	MCPA
GC/ECD	8151A	MCPP (Mecoprop)

Solid and Chemical Materials		
Technology	Method	Analyte
HPLC/UV	8330A	1,3,5-Trinitrobenzene
HPLC/UV	8330A	1,3-Dinitrobenzene
HPLC/UV	8330A	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	8330A	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	8330A	2,4-Dinitrotoluene (DNT)
HPLC/UV	8330A	2,6-Dinitrotoluene
HPLC/UV	8330A	2-Amino-4,6-dinitrotoluene
HPLC/UV	8330A	2-Nitrotoluene (ONT)
HPLC/UV	8330A	3-Nitrotoluene
HPLC/UV	8330A	4-Amino-2,6-dinitrotoluene
HPLC/UV	8330A	4-Nitrotoluene (PNT)
HPLC/UV	8330A	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	8330A	Nitroglycerin
HPLC/UV	8330A	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	8330A	PETN
GC/FID	8015B	TPH DRO
GC/FID	8015B	TPH GRO
HPLC/MS	6850	Perchlorate
ICP	6010B/C	Aluminum
ICP	6010B/C	Antimony
ICP	6010B/C	Arsenic
ICP	6010B/C	Barium
ICP	6010B/C	Beryllium
ICP	6010B/C	Cadmium
ICP	6010B/C	Calcium
ICP	6010B/C	Chromium, total
ICP	6010B/C	Cobalt
ICP	6010B/C	Copper
ICP	6010B/C	Iron
ICP	6010B/C	Lead
ICP	6010B/C	Magnesium
ICP	6010B/C	Manganese
CVAA	7471A/B	Mercury
ICP	6010B/C	Nickel
ICP	6010B/C	Potassium
ICP	6010B/C	Selenium
ICP	6010B/C	Silver
ICP	6010B/C	Sodium
ICP	6010B/C	Thallium

Solid and Chemical Materials		
Technology	Method	Analyte
ICP	6010B/C	Vanadium
ICP	6010B/C	Zinc
ICP	6010B/C	Molybdenum
ICP	6010B/C	Tin
ICP	6010B/C	Titanium
UV/Vis	7196A	Hexavalent Chromium
TOC	Lloyd Kahn	Total Organic Carbon
Colorimetric	9012A/B	Cyanide
Titration	Chap.7, Sect. 7.3.4 Mod.	Reactive Sulfide
Titration	9034	Sulfide
Probe	9045D	pH
Preparation	Method	Type
Preparation	1311	TCLP
Preparation	1312	SPLP
Preparation	NJ Modified 3060A	Hexavalent Chromium
Preparation	3050B	Metals Digestion
Preparation	3546	Organics Microwave Extraction
Preparation	3541	Organics Soxhlet Extraction
Preparation	3550B	Organics Sonication
Preparation	SM 2540B 20th edition	Percent Solids (Percent Moisture)
Preparation	5035 /A	Purge and Trap Solid

Notes:

- 1) This laboratory offers commercial testing service.

Approved By: _____



R. Douglas Leonard
Chief Technical Officer

Date: November 30, 2009

Issued: 11/30/09



SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

CAPE FEAR ANALYTICAL, LLC
 3306 Kitty Hawk Road, Suite 120
 Wilmington, NC 28405
 W. Michael Larkins Phone: 910-795-0421
 mlarkins@cfanalytical.com

ENVIRONMENTAL

Valid To: May 31, 2012

Certificate Number: 3014.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.1)) accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

High Resolution Gas Chromatography / Mass Spectrometry

Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste
2,3,7,8-Tetrachlorodibenzo-p-dioxin	EPA 1613B	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,4,5,6,7,8-Octachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
2,3,7,8-Tetrachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,7,8-Pentachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
2,3,4,7,8-Pentachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,4,7,8-Hexachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,6,7,8-Hexachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
2,3,4,6,7,8-Hexachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,7,8,9-Hexachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,4,6,7,8-Heptachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,4,7,8,9-Heptachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
1,2,3,4,5,6,7,8-Octachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
Total Tetrachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
Total Pentachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
Total Hexachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A
Total Heptachlorodibenzo-p-dioxin	-----	EPA 1613B/8290A	EPA 1613B/8290A

Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste
Total Tetrachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
Total Pentachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
Total Hexachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
Total Heptachlorodibenzofuran	-----	EPA 1613B/8290A	EPA 1613B/8290A
2-Chlorobiphenyl (1)	-----	EPA 1668A	EPA 1668A
3-Chlorobiphenyl (2)	-----	EPA 1668A	EPA 1668A
4-Chlorobiphenyl (3)	-----	EPA 1668A	EPA 1668A
2,2'-Dichlorobiphenyl (4)	-----	EPA 1668A	EPA 1668A
2,3-Dichlorobiphenyl (5)	-----	EPA 1668A	EPA 1668A
2,3'-Dichlorobiphenyl (6)	-----	EPA 1668A	EPA 1668A
2,4-Dichlorobiphenyl (7)	-----	EPA 1668A	EPA 1668A
2,4'-Dichlorobiphenyl (8)	-----	EPA 1668A	EPA 1668A
2,5-Dichlorobiphenyl (9)	-----	EPA 1668A	EPA 1668A
2,6-Dichlorobiphenyl (10)	-----	EPA 1668A	EPA 1668A
3,3'-Dichlorobiphenyl (11)	-----	EPA 1668A	EPA 1668A
3,4-Dichlorobiphenyl (12)	-----	EPA 1668A	EPA 1668A
3,4'-Dichlorobiphenyl (13)	-----	EPA 1668A	EPA 1668A
3,5-Dichlorobiphenyl (14)	-----	EPA 1668A	EPA 1668A
4,4'-Dichlorobiphenyl (15)	-----	EPA 1668A	EPA 1668A
2,2',3-Trichlorobiphenyl (16)	-----	EPA 1668A	EPA 1668A
2,2',4-Trichlorobiphenyl (17)	-----	EPA 1668A	EPA 1668A
2,2',5-Trichlorobiphenyl (18)	-----	EPA 1668A	EPA 1668A
2,2',6-Trichlorobiphenyl (19)	-----	EPA 1668A	EPA 1668A
2,3,3'-Trichlorobiphenyl (20)	-----	EPA 1668A	EPA 1668A
2,3,4-Trichlorobiphenyl (21)	-----	EPA 1668A	EPA 1668A
2,3,4'-Trichlorobiphenyl (22)	-----	EPA 1668A	EPA 1668A
2,3,5-Trichlorobiphenyl (23)	-----	EPA 1668A	EPA 1668A
2,3,6-Trichlorobiphenyl (24)	-----	EPA 1668A	EPA 1668A
2,3',4-Trichlorobiphenyl (25)	-----	EPA 1668A	EPA 1668A
2,3',5-Trichlorobiphenyl (26)	-----	EPA 1668A	EPA 1668A
2,3',6-Trichlorobiphenyl (27)	-----	EPA 1668A	EPA 1668A
2,4,4'-Trichlorobiphenyl (28)	-----	EPA 1668A	EPA 1668A
2,4,5-Trichlorobiphenyl (29)	-----	EPA 1668A	EPA 1668A
2,4,6-Trichlorobiphenyl (30)	-----	EPA 1668A	EPA 1668A
2,4',5-Trichlorobiphenyl (31)	-----	EPA 1668A	EPA 1668A
2,4',6-Trichlorobiphenyl (32)	-----	EPA 1668A	EPA 1668A
2',3,4-Trichlorobiphenyl (33)	-----	EPA 1668A	EPA 1668A
2',3,5-Trichlorobiphenyl (34)	-----	EPA 1668A	EPA 1668A
3,3',4-Trichlorobiphenyl (35)	-----	EPA 1668A	EPA 1668A
3,3',5-Trichlorobiphenyl (36)	-----	EPA 1668A	EPA 1668A
3,4,4'-Trichlorobiphenyl (37)	-----	EPA 1668A	EPA 1668A
3,4,5-Trichlorobiphenyl (38)	-----	EPA 1668A	EPA 1668A
3,4',5-Trichlorobiphenyl (39)	-----	EPA 1668A	EPA 1668A
2,2',3,3'-Tetrachlorobiphenyl (40)	-----	EPA 1668A	EPA 1668A
2,2',3,4-Tetrachlorobiphenyl (41)	-----	EPA 1668A	EPA 1668A
2,2',3,4'-Tetrachlorobiphenyl (42)	-----	EPA 1668A	EPA 1668A
2,2',3,5-Tetrachlorobiphenyl (43)	-----	EPA 1668A	EPA 1668A
2,2',3,5'-Tetrachlorobiphenyl (44)	-----	EPA 1668A	EPA 1668A
2,2',3,6-Tetrachlorobiphenyl (45)	-----	EPA 1668A	EPA 1668A
2,2',3,6'-Tetrachlorobiphenyl (46)	-----	EPA 1668A	EPA 1668A
2,2',4,4'-Tetrachlorobiphenyl (47)	-----	EPA 1668A	EPA 1668A

Peter Abney

Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste
2,2',4,5-Tetrachlorobiphenyl (48)	-----	EPA 1668A	EPA 1668A
2,2',4,5'-Tetrachlorobiphenyl (49)	-----	EPA 1668A	EPA 1668A
2,2',4,6-Tetrachlorobiphenyl (50)	-----	EPA 1668A	EPA 1668A
2,2',4,6'-Tetrachlorobiphenyl (51)	-----	EPA 1668A	EPA 1668A
2,2',5,5'-Tetrachlorobiphenyl (52)	-----	EPA 1668A	EPA 1668A
2,2',5,6'-Tetrachlorobiphenyl (53)	-----	EPA 1668A	EPA 1668A
2,2',6,6'-Tetrachlorobiphenyl (54)	-----	EPA 1668A	EPA 1668A
2,3,3',4-Tetrachlorobiphenyl (55)	-----	EPA 1668A	EPA 1668A
2,3,3',4'-Tetrachlorobiphenyl (56)	-----	EPA 1668A	EPA 1668A
2,3,3',5-Tetrachlorobiphenyl (57)	-----	EPA 1668A	EPA 1668A
2,3,3',5'-Tetrachlorobiphenyl (58)	-----	EPA 1668A	EPA 1668A
2,3,3',6-Tetrachlorobiphenyl (59)	-----	EPA 1668A	EPA 1668A
2,3,4,4'-Tetrachlorobiphenyl (60)	-----	EPA 1668A	EPA 1668A
2,3,4,5-Tetrachlorobiphenyl (61)	-----	EPA 1668A	EPA 1668A
2,3,4,6-Tetrachlorobiphenyl (62)	-----	EPA 1668A	EPA 1668A
2,3,4',5-Tetrachlorobiphenyl (63)	-----	EPA 1668A	EPA 1668A
2,3,4',6-Tetrachlorobiphenyl (64)	-----	EPA 1668A	EPA 1668A
2,3,5,6-Tetrachlorobiphenyl (65)	-----	EPA 1668A	EPA 1668A
2,3',4,4'-Tetrachlorobiphenyl (66)	-----	EPA 1668A	EPA 1668A
2,3',4,5-Tetrachlorobiphenyl (67)	-----	EPA 1668A	EPA 1668A
2,3',4,5'-Tetrachlorobiphenyl (68)	-----	EPA 1668A	EPA 1668A
2,3',4,6-Tetrachlorobiphenyl (69)	-----	EPA 1668A	EPA 1668A
2,3',4',5-Tetrachlorobiphenyl (70)	-----	EPA 1668A	EPA 1668A
2,3',4',6-Tetrachlorobiphenyl (71)	-----	EPA 1668A	EPA 1668A
2,3',5,5'-Tetrachlorobiphenyl (72)	-----	EPA 1668A	EPA 1668A
2,3',5',6-Tetrachlorobiphenyl (73)	-----	EPA 1668A	EPA 1668A
2,4,4',5-Tetrachlorobiphenyl (74)	-----	EPA 1668A	EPA 1668A
2,4,4',6-Tetrachlorobiphenyl (75)	-----	EPA 1668A	EPA 1668A
2',3,4,5-Tetrachlorobiphenyl (76)	-----	EPA 1668A	EPA 1668A
3,3',4,4'-Tetrachlorobiphenyl (77)	-----	EPA 1668A	EPA 1668A
3,3',4,5-Tetrachlorobiphenyl (78)	-----	EPA 1668A	EPA 1668A
3,3',4,5'-Tetrachlorobiphenyl (79)	-----	EPA 1668A	EPA 1668A
3,3',5,5'-Tetrachlorobiphenyl (80)	-----	EPA 1668A	EPA 1668A
3,4,4',5-Tetrachlorobiphenyl (81)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4-Pentachlorobiphenyl (82)	-----	EPA 1668A	EPA 1668A
2,2',3,3',5-Pentachlorobiphenyl (83)	-----	EPA 1668A	EPA 1668A
2,2',3,3',6-Pentachlorobiphenyl (84)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4'-Pentachlorobiphenyl (85)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5-Pentachlorobiphenyl (86)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5'-Pentachlorobiphenyl (87)	-----	EPA 1668A	EPA 1668A
2,2',3,4,6-Pentachlorobiphenyl (88)	-----	EPA 1668A	EPA 1668A
2,2',3,4,6'-Pentachlorobiphenyl (89)	-----	EPA 1668A	EPA 1668A
2,2',3,4',5-Pentachlorobiphenyl (90)	-----	EPA 1668A	EPA 1668A
2,2',3,4',6-Pentachlorobiphenyl (91)	-----	EPA 1668A	EPA 1668A
2,2',3,5,5'-Pentachlorobiphenyl (92)	-----	EPA 1668A	EPA 1668A
2,2',3,5,6-Pentachlorobiphenyl (93)	-----	EPA 1668A	EPA 1668A
2,2',3,5,6'-Pentachlorobiphenyl (94)	-----	EPA 1668A	EPA 1668A
2,2',3,5',6-Pentachlorobiphenyl (95)	-----	EPA 1668A	EPA 1668A
2,2',3,6,6'-Pentachlorobiphenyl (96)	-----	EPA 1668A	EPA 1668A
2,2',3',4,5-Pentachlorobiphenyl (97)	-----	EPA 1668A	EPA 1668A
2,2',3',4,6-Pentachlorobiphenyl (98)	-----	EPA 1668A	EPA 1668A

Peter Abney

Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste
2,2',4,4',5-Pentachlorobiphenyl (99)	-----	EPA 1668A	EPA 1668A
2,2',4,4',6-Pentachlorobiphenyl (100)	-----	EPA 1668A	EPA 1668A
2,2',4,5,5'-Pentachlorobiphenyl (101)	-----	EPA 1668A	EPA 1668A
2,2',4,5,6'-Pentachlorobiphenyl (102)	-----	EPA 1668A	EPA 1668A
2,2',4,5',6-Pentachlorobiphenyl (103)	-----	EPA 1668A	EPA 1668A
2,2',4,6,6'-Pentachlorobiphenyl (104)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4'-Pentachlorobiphenyl (105)	-----	EPA 1668A	EPA 1668A
2,3,3',4,5-Pentachlorobiphenyl (106)	-----	EPA 1668A	EPA 1668A
2,3,3',4',5-Pentachlorobiphenyl (107)	-----	EPA 1668A	EPA 1668A
2,3,3',4,5'-Pentachlorobiphenyl (108)	-----	EPA 1668A	EPA 1668A
2,3,3',4,6-Pentachlorobiphenyl (109)	-----	EPA 1668A	EPA 1668A
2,3,3',4',6-Pentachlorobiphenyl (110)	-----	EPA 1668A	EPA 1668A
2,3,3',5,5'-Pentachlorobiphenyl (111)	-----	EPA 1668A	EPA 1668A
2,3,3',5,6-Pentachlorobiphenyl (112)	-----	EPA 1668A	EPA 1668A
2,3,3',5',6-Pentachlorobiphenyl (113)	-----	EPA 1668A	EPA 1668A
2,3,4,4',5-Pentachlorobiphenyl (114)	-----	EPA 1668A	EPA 1668A
2,3,4,4',6-Pentachlorobiphenyl (115)	-----	EPA 1668A	EPA 1668A
2,3,4,5,6-Pentachlorobiphenyl (116)	-----	EPA 1668A	EPA 1668A
2,3,4',5,6-Pentachlorobiphenyl (117)	-----	EPA 1668A	EPA 1668A
2,3',4,4',5-Pentachlorobiphenyl (118)	-----	EPA 1668A	EPA 1668A
2,3',4,4',6-Pentachlorobiphenyl (119)	-----	EPA 1668A	EPA 1668A
2,3',4,5,5'-Pentachlorobiphenyl (120)	-----	EPA 1668A	EPA 1668A
2,3',4,5',6-Pentachlorobiphenyl (121)	-----	EPA 1668A	EPA 1668A
2',3,3',4,5-Pentachlorobiphenyl (122)	-----	EPA 1668A	EPA 1668A
2',3,4,4',5-Pentachlorobiphenyl (123)	-----	EPA 1668A	EPA 1668A
2',3,4,5,5'-Pentachlorobiphenyl (124)	-----	EPA 1668A	EPA 1668A
2',3,4,5,6'-Pentachlorobiphenyl (125)	-----	EPA 1668A	EPA 1668A
3,3',4,4',5-Pentachlorobiphenyl (126)	-----	EPA 1668A	EPA 1668A
3,3',4,5,5'-Pentachlorobiphenyl (127)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4'-Hexachlorobiphenyl (128)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5-Hexachlorobiphenyl (129)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5'-Hexachlorobiphenyl (130)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,6-Hexachlorobiphenyl (131)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,6'-Hexachlorobiphenyl (132)	-----	EPA 1668A	EPA 1668A
2,2',3,3',5,5'-Hexachlorobiphenyl (133)	-----	EPA 1668A	EPA 1668A
2,2',3,3',5,6-Hexachlorobiphenyl (134)	-----	EPA 1668A	EPA 1668A
2,2',3,3',5,6'-Hexachlorobiphenyl (135)	-----	EPA 1668A	EPA 1668A
2,2',3,3',6,6'-Hexachlorobiphenyl (136)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5-Hexachlorobiphenyl (137)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5'-Hexachlorobiphenyl (138)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',6-Hexachlorobiphenyl (139)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',6'-Hexachlorobiphenyl (140)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,5'-Hexachlorobiphenyl (141)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,6-Hexachlorobiphenyl (142)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,6'-Hexachlorobiphenyl (143)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5',6-Hexachlorobiphenyl (144)	-----	EPA 1668A	EPA 1668A
2,2',3,4,6,6'-Hexachlorobiphenyl (145)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,5'-Hexachlorobiphenyl (146)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,6-Hexachlorobiphenyl (147)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,6'-Hexachlorobiphenyl (148)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5',6-Hexachlorobiphenyl (149)	-----	EPA 1668A	EPA 1668A

Peter Mlynar

Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste
2,2',3,4',6,6'-Hexachlorobiphenyl (150)	-----	EPA 1668A	EPA 1668A
2,2',3,5,5',6-Hexachlorobiphenyl (151)	-----	EPA 1668A	EPA 1668A
2,2',3,5,6,6'-Hexachlorobiphenyl (152)	-----	EPA 1668A	EPA 1668A
2,2',4,4',5,5'-Hexachlorobiphenyl (153)	-----	EPA 1668A	EPA 1668A
2,2',4,4',5',6-Hexachlorobiphenyl (154)	-----	EPA 1668A	EPA 1668A
2,2',4,4',6,6'-Hexachlorobiphenyl (155)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4',5-Hexachlorobiphenyl (156)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4',5'-Hexachlorobiphenyl (157)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4',6-Hexachlorobiphenyl (158)	-----	EPA 1668A	EPA 1668A
2,3,3',4,5,5'-Hexachlorobiphenyl (159)	-----	EPA 1668A	EPA 1668A
2,3,3',4,5,6-Hexachlorobiphenyl (160)	-----	EPA 1668A	EPA 1668A
2,3,3',4,5',6-Hexachlorobiphenyl (161)	-----	EPA 1668A	EPA 1668A
2,3,3',4',5,5'-Hexachlorobiphenyl (162)	-----	EPA 1668A	EPA 1668A
2,3,3',4',5,6-Hexachlorobiphenyl (163)	-----	EPA 1668A	EPA 1668A
2,3,3',4',5',6-Hexachlorobiphenyl (164)	-----	EPA 1668A	EPA 1668A
2,3,3',5,5',6-Hexachlorobiphenyl (165)	-----	EPA 1668A	EPA 1668A
2,3,4,4',5,6-Hexachlorobiphenyl (166)	-----	EPA 1668A	EPA 1668A
2,3',4,4',5,5'-Hexachlorobiphenyl (167)	-----	EPA 1668A	EPA 1668A
2,3',4,4',5',6-Hexachlorobiphenyl (168)	-----	EPA 1668A	EPA 1668A
3,3',4,4',5,5'-Hexachlorobiphenyl (169)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',5-Heptachlorobiphenyl (170)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',6-Heptachlorobiphenyl (171)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5,5'-Heptachlorobiphenyl (172)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5,6-Heptachlorobiphenyl (173)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5,6'-Heptachlorobiphenyl (174)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5',6-Heptachlorobiphenyl (175)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,6,6'-Heptachlorobiphenyl (176)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4',5,6-Heptachlorobiphenyl (177)	-----	EPA 1668A	EPA 1668A
2,2',3,3',5,5',6-Heptachlorobiphenyl (178)	-----	EPA 1668A	EPA 1668A
2,2',3,3',5,6,6'-Heptachlorobiphenyl (179)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5,5'-Heptachlorobiphenyl (180)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5,6-Heptachlorobiphenyl (181)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5,6'-Heptachlorobiphenyl (182)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5',6-Heptachlorobiphenyl (183)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',6,6'-Heptachlorobiphenyl (184)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,5',6-Heptachlorobiphenyl (185)	-----	EPA 1668A	EPA 1668A
2,2',3,4,5,6,6'-Heptachlorobiphenyl (186)	-----	EPA 1668A	EPA 1668A
2,2',3,4',5,5',6-Heptachlorobiphenyl (187)	-----	EPA 1668A	EPA 1668A
2,2',3,4',5,6,6'-Heptachlorobiphenyl (188)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4',5,5'-Heptachlorobiphenyl (189)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4',5,6-Heptachlorobiphenyl (190)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4',5',6-Heptachlorobiphenyl (191)	-----	EPA 1668A	EPA 1668A
2,3,3',4,5,5',6-Heptachlorobiphenyl (192)	-----	EPA 1668A	EPA 1668A
2,3,3',4',5,5',6-Heptachlorobiphenyl (193)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',5,5'-Octachlorobiphenyl (194)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',5,6-Octachlorobiphenyl (195)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',5,6'-Octachlorobiphenyl (196)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',6,6'-Octachlorobiphenyl (197)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5,5',6-Octachlorobiphenyl (198)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5,5',6'-Octachlorobiphenyl (199)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5,6,6'-Octachlorobiphenyl (200)	-----	EPA 1668A	EPA 1668A

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Parameter/Analyte	Potable Water	Nonpotable Water	Solid Hazardous Waste
2,2',3,3',4,5',6,6'-Octachlorobiphenyl (201)	-----	EPA 1668A	EPA 1668A
2,2',3,3',5,5',6,6'-Octachlorobiphenyl (202)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5,5',6-Octachlorobiphenyl (203)	-----	EPA 1668A	EPA 1668A
2,2',3,4,4',5,6,6'-Octachlorobiphenyl (204)	-----	EPA 1668A	EPA 1668A
2,3,3',4,4',5,5',6-Octachlorobiphenyl (205)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (206)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl (207)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl (208)	-----	EPA 1668A	EPA 1668A
2,2',3,3',4,4',5,5',6,6'-Decachlorobiphenyl (209)	-----	EPA 1668A	EPA 1668A
Soxhlet/Dean-Stark Extraction	-----	-----	EPA 3540C
Continuous Liquid-Liquid Extraction	EPA 3520C	-----	-----





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In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (QSM v4.1); accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (refer to *joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

Presented this 5th day of April 2010.



A handwritten signature in black ink, appearing to read "Peter Almy".

President & CEO
For the Accreditation Council
Certificate Number 3014.01
Valid to May 31, 2012

For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.