Uniform Federal Policy - Quality Assurance Project Plan

Alabama Army National Guard Organizational Maintenance Shop #28 Mobile, Alabama

Contract No.: W90FYQ-10-D-0010
TASK ORDER NO.: CK02

Prepared for:
United States Army Corp of Engineers, Mobile District
United States Army National Guard

Alabama Army National Guard Mobile AL	109 St. Joseph Street Mobile AL 36602

Prepared by:
AECOM TECHNICAL SERVICES, INC.
GREENVILLE, SC

January 2016

This work plan includes data that shall not be disclosed outside the Government and shall not be duplicated, used or disclosed—in whole or in part—for any purpose other than in support of this project

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Uniform Federal Policy - Quality Assurance Project Plan

Alabama Army National Guard
Organizational Maintenance Shop #28

Supplemental Data Gap Investigation
Mobile, Alabama

Prepared for
United States Army National Guard

Prepared by
AECOM Technical Services, Inc., Greenville, SC

CONTRACT NO. W90FYQ-10-D-0010
TASK ORDER NO. CK02

Under Contract to
United States Army Corps of Engineers
South Atlantic Division, Mobile District
109 Saint Joseph Street
Mobile, Alabama 36602

I hereby submit that I am currently registered in good standing as a Professional Geologist in the state of Alabama. To the best of my knowledge, all of the methods proposed within this Supplemental Data Gap Investigation UFP-QAPP are in accordance with applicable state and federal regulations and accepted professional practices.

ROBERT DUNN HENRY
LIC. #1097

Robert Dunn Henry

Robert Dunn Henry, P.G.
Alabama Registration No. AL1097
Expiration Date: November 30, 2017

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LIST OF ACRONYMS AND ABBREVIATIONS

ADEM	Alabama Department of Environmental Management
AECOM	AECOM Technical Services, Inc.
AEIRG	Alabama Environmental Investigation and Remediation Guidance
AFB	Air Force Base
ALARNG	Alabama Army National Guard
ARBCA	Alabama Risk-Based Corrective Action
ARNG	Army National Guard
ASTM	American Standard for Testing and Materials
bgs	below ground surface
BRA	baseline risk assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	code of federal regulations
CoC	chain of custody
COC	chemical of concern
COPC	chemical of potential concern
COR	Contracting Officer's Representative
CSM	conceptual site model
DoD	Department of Defense
DO	dissolved oxygen
DOT	Department of Transportation
DPT	direct push technology
DQI	data quality indicator
DQO	data quality objective
EC	electrical conductance
EDD	electronic data deliverable
ELAP	environmental laboratory accreditation program
FID	flame ionization detector
FMS	field maintenance shop
FS	feasibility study
GC	gas chromatography
GCAL	Gulf Coast Analytical Laboratories
GPS	global positioning system
HPT	hydraulic profiling tool
IDQTF	Intergovernmental Data Quality Task Force
IDW	investigation-derived waste
in/yr	inches per year
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LLMIP	low level membrane interface probe
LOD	limit of detection
LOQ	limit of quantitation
MAA	Mobile Airport Authority
MCL	maximum contaminant level
MDL	method detection limit
Mgal/day	million gallons per day
mg/kg	milligrams per kilogram
mL	milliliter
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
N/A	not applicable
OMS	organizational maintenance shop

ORP	oxidation reduction potential
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCE	tetrachloroethene
PID	photoionization detector
PM	project manager
PQO	project quality objective
PSC	project screening criteria
PSV	preliminary screening value
PWS	performance work statement
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QSM	quality systems manual
RI	remedial investigation
RL	reporting limit
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
RSL	regional screening level
SAIC	Scientific Applications International Corporation
SDG	sample delivery group
SOP	standard operating procedure
SSHP	site safety and health plan
SSL	soil screening level
TCE	trichloroethene
TCL	target compound list
UFP	Uniform Federal Policy
USACE	U.S. Army Corps of Engineers
UST	underground storage tank
VOC	volatile organic compound
WP	work plan
^{o}C	degree Celsius
µg/L	micrograms per liter
USCS	unified soil classification system
USEPA, EPA	U.S. Environmental Protection Agency

WORKSHEET #1: TITLE AND APPROVAL PAGE

Alabama Army National Guard (ALARNG) Organizational Maintenance Shop (OMS) #28 Supplemental Data Gap Investigation UFP-QAPP
Document Title

United States Army National Guard
Lead Organization

AECOM Technical Services, Inc. (AECOM)
Preparer's Name and Organizational Affiliation

AECOM Technical Services, Inc.
10 Patewood Drive, Building VI, Suite 500, Greenville, SC 29615
864-234-3000
Preparer's Address, Telephone Number

08 January 2016
Preparation Date (Date/Month/Year)

Holt, Steve
Digitally signed by Holt, Steve
Date: 2016.01.06 16:36:22 -05'00'

Investigative Organization's:
Project Manager
Steve A. Holt, AECOM

Kourlas, Vasi
Digitally signed by Kourlas, Vasi
DN: dc=com, dc=aecomnet, dc=na, ou=AECOMUsers, ou=USSouth, ou=USGRN1, cn=Kourlas, Vasi
Date: 2016.01.05 11:08:11 -05'00'

Investigative Organization's:
Quality Assurance Manager
Vasi Kourlas, AECOM

Digitally signed by SHIRLEY.MELISSA.L.1121192981
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=SHIRLEY.MELISSA.L.1121192981
Date: 2016.01.06 15:47:56 -06'00'

United States Army Corps of Engineers
Mobile District
Melissa Shirley, CESAM-EN-GE

MERKEL.BRETT.A.1299941139
Digitally signed by MERKEL.BRETT.A.1299941139
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=MERKEL.BRETT.A.1299941139
Date: 2016.01.07 08:44:22 -05'00'

Lead Organization's:
Approving Authority
Brett Merkel, ARNG-ILE Clean Up

Approval Signature:

Alabama Department of Environmental
Management Approving Authority
Colin Mitchell

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WORKSHEET #2: WORK PLAN IDENTIFYING INFORMATION

Site Name/Project Name:	Alabama Army National Guard OMS #28
Site Location:	Mobile, Alabama
Contractor Name:	AECOM Technical Services, Inc.
Contract Number:	W90FYQ-10-D-0010
Contract Title:	Nationwide Architect-Engineer services
Delivery Order:	CK02
Revision Number:	0

1. This UFP-QAPP was prepared in accordance with the following requirements:
    - *Intergovernmental Data Quality Task Force (IDQTF) Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPPs); Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs, Part 1: UFP-QAPP Manual* (IDQTF, 2005a), United States Environmental Protection Agency (USEPA) publication number *EPA-505-B-04-900A* or United States Department of Defense (DoD) publication number *DTIC ADA 427785*;
    - *IDQTF Workbooks for UFP-QAPPs, Evaluating, Assessing, and Documenting Environmental Data Collection and Use Programs, Part 2A: UFP-QAPP Workbook* (IDQTF, 2005b), USEPA publication number *EPA-505-B-04-900C* or DoD publication number *DTIC ADA 427486*;
    - IDQTF, *UFP-QAPPs, Part 2B: Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (IDQTF, 2005c), USEPA publication number *EPA-505-B-04-900B* or DoD publication number *DTIC ADA 426957;* and
    - *DoD Quality Systems Manual (QSM) for Environmental Laboratories, Version 5* (DoD, July 2013).
    - *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA; USEPA, October 1998).
    - *Alabama Risk-Based Corrective Action Guidance Manual (ARBCA; Alabama Department of Environmental Management [ADEM], 2008).*
    - *Alabama Environmental Investigation and Remedial Guidance* (AEIRG; ADEM, 2005).
    - Defense Environmental Restoration Project (DERP), Department of Defense (DoD), Number 4715.20, March 9, 2012.
2. Identify regulatory program:
    - CERCLA
3. This UFP-QAPP covers Organizational Maintenance Shop Number 28 (OMS #28).
4. List dates of sessions that were held:
    - Site Walk on 02 September 2015
    - ADEM Partnering Meeting in Montgomery, AL on 12 November 2015.

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

    - A comprehensive list of WPs and reports are listed on the Administrative Records website for ALARNG OMS #28 at: http://www.mobileoms28.net/oms28/Website%20Admin%20Record/OMS-28-Admin-Record-Index.pdf

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

Organization Partners / Stakeholders	**Role**
United States Army National Guard (ARNG)	Lead Organization
Alabama Army National Guard (ALARNG)	Compliance Support
United States Army Corp of Engineers (USACE), Mobile District	Support Agency
ADEM	Regulatory Organization
AECOM	Contractor

7. Lead organization: ARNG

8. If any required UFP-QAPP Worksheets and required information are not applicable to the project or are provided elsewhere, then note the omitted Worksheets and provide an explanation for their exclusion below:

    All worksheet elements are applicable to the project.

Worksheet #	Required Information	Crosswalk to Related Information*
A. Project Management and Objectives		
Documentation		
1	Title and Approval Page	
2	Work Plan Identifying Information	
3	Distribution List	
4	Project Personnel Sign-Off Sheet	
Project Organization		
5	Project Organization Chart	
6	Communication Pathways	
7	Personnel Responsibility Table	
8	Special Personnel Training Requirements Table	
Project Planning/Problem Definition		
9	Project Scoping Session Participants Sheet	
10	Conceptual Site Model	
11	Project Quality Objectives/Systematic Planning Process Statements	
12	Field Quality Control Samples	
13	Secondary Data Criteria and Limitations Table	
14	Summary of Project Tasks	
15	Reference Limits and Evaluation Tables	
16	Project Schedule/Timeline Table	
B. Measurement/Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	
18	Location-Specific Sampling Methods/SOP Requirements Table	
19	Field Sampling Requirements Table	
20	Field Quality Control Sample Summary Table	
21	Project Sampling SOP References Table	
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	
Analytical Tasks		
23	Analytical SOP Reference Table	
24	Analytical Instrument Calibration Table	
25	Analytical Instrument and Equip Maintenance, Testing, & Inspection Table	
Sample Collection		
26	Analytical Instrument and Equipment, Testing and Inspection Table	
27	Sample Custody Requirements	
Quality Control Samples		
28	Laboratory QC Samples Table	
Data Management Tasks		
29	Project Documents and Records Table	
30	Worksheet #30: Analytical Services	
C. Assessment Oversight		
31	Worksheet #31: Planned Project Assessments	
32	Assessment Findings and Corrective Action Responses	
33	Quality Assurance Management Reports Table	

Worksheet #	Required Information	Crosswalk to Related Information*
D. Data Review		
34-36	Worksheets #34-36: Data Verification and Validation	
37	WORKSHEET #37: Usability Assessment	

* Crosswalk to other project planning or support documents.

The Site Safety and Health Plan (SSHP) for the field investigation is submitted as a separate document.

WORKSHEET #3: DISTRIBUTION LIST

Copies of plans and reports will be submitted in accordance with the following table. Following each submission, comments generated as a result of the Government's review, and furnished to the Contractor, shall be incorporated into the final document. The final plans and the final reports will include a compact disk (text in PDF and Microsoft Word format; GIS drawings in PDF and shape files) shall be submitted to the USACE Contracting Officer's Representative (COR) in accordance with the following table. Draft submittals shall have numbered lines where applicable. All native files shall be provided.

Recipient	draft WP and sub-plans	final WP and sub-plans	draft (and revised final, if necessary) data reports	final (and revised final, if necessary) data reports
USACE COR, Melissa Shirley	electronic	1 hard copy with CD	electronic	1 hard copy with CD and 1 CD of all native files
ADEM, Colin Mitchell	none	2 hard copies each with CD	none	2 hard copies each with CD
ARNG, Brett Merkel	electronic	1 hard copy with CD	electronic	1 hard copy with CD and 1 CD of all native files
ALARNG, Sheri Festoso	electronic	1 hard copy with CD	electronic	1 hard copy with CD and 1 CD of all native files
Mobile Airport Authority (MAA), Roger Wehner	none	1 hard copy with CD	none	1 hard copy with CD

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WORKSHEET #4: PROJECT PERSONNEL SIGN-OFF SHEET

Project Personnel	Organization, Title	Telephone Number	Signature/E-mail Receipt	WP Section Reviewed	Date WP Read
Steve Holt	AECOM, Project Manager	864-234-2260			
Robert Dunn Henry	AECOM, Sr. Geologist	404-965-9703			
Brett Merkel	ARNG-ILE Clean Up	703-601-7785			
Melissa Shirley	USACE, COR	251-690-2616			
Sheri Festoso	ALARNG, Compliance Manager	334-271-8183			
Colin Mitchell	ADEM	334-271-7730			

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WORKSHEET #5: PROJECT ORGANIZATIONAL CHART

Lines of Communication

Lines of Authority

Army National Guard
Brett Merkel
(ILE Cleanup)

Mobile Airport Authority
Roger E Wehner

USACE Mobile
Melissa Shirley
(COR)

Alabama Army National Guard
Sheri Festoso
(Compliance)

Field Maintanence Shop 28
Chief Gibbs
____
Chief Trawic
(Assistant Shop Supervisor)

AECOM
Steve Holt
(Project Manager)

Vasi Kourlas
(Technical Lead / Deputy Project Manager)

Steve Duda
(Risk Assessor)

Robert Dunn Henry
(Alabama PG/ Field Manager)

Tony Indorato
(Certified Safety Officer)

Dwight Parks
(Project Chemist)

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WORKSHEET #6: COMMUNICATION PATHWAYS

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
Regulatory Agency Interface	ARNG, ILE Cleanup	Brett Merkel	703-601-7785	All project documentation will be forwarded by the USACE COR. The ARNG will be responsible for notifying ADEM when significant corrective actions or changes occur. Corrective actions will be communicated within 24 hours.
Contract Management	USACE COR	Melissa Shirley	251-690-2616	All project contract documentation will be forwarded to the USACE Contracting Officer's Representative (COR). The USACE will be responsible for notifying the ARNG when significant corrective actions or changes occur. Corrective actions will be communicated within 24 hours. All project documentation will be forwarded by the USACE COR. She will be responsible for notifying and scheduling USACE project staff of implementation of field activities and conducting technical reviews of documents and reports.
Project Management	AECOM PM	Steve Holt	864-234-2260	The AECOM project manager (PM) will direct and approve all communication to the USACE's COR and provide monthly status reports to the USACE COR. The AECOM PM will notify the USACE COR of field changes or modifications by close of business the following day.
Initiation, notification and/or approval of modifications	AECOM Contracts Manager	Joe Mazzone	864-234-3026	Contract Delivery Orders and modifications will be reviewed and submitted between the USACE Contracting Officer and AECOM's Contracts Manager.
QA/QC Management	AECOM QA Program Manager	Ashley Bray	864-234-3565	The AECOM QA program manager will designate responsible project quality personnel to perform specified QA and QC activities and report to project management. Issues, non-conformances, and corrective actions will be reported to the USACE COR within 1 day of non-conformance issuance.
Field Progress Reports	AECOM Field Manager	Dunn Henry	404-965-9703	The AECOM field manager will communicate relevant field information to the AECOM PM and AECOM task manager during field activities by phone or e-mail.
Stop Work due to Safety Issues	AECOM Health & Safety Coordinator or AECOM Field Manager	Tony Indorato	813-645-2804	The AECOM health and safety coordinator will communicate with the AECOM field manager and both will have the authority to stop work by field subcontractors or field sampling personnel. Field work will restart upon satisfactory implementation of the appropriate corrective actions. All field personnel have stop work authority if they feel there are safety concerns.
WP Changes prior to Field/ Laboratory work	AECOM PM	Steve Holt	864.234.2260	Substantial changes to the planning documents will require the AECOM PM to prepare amended worksheets before the activities begin.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure
WP Changes in the Field	AECOM Field Manager	Dunn Henry	404-965-9703	The AECOM field manager will notify the project manager of changes to the procedures specified in the WP during field activities. The AECOM PM will determine the appropriate course of action and document these changes in the site investigation report.
Field Corrective Actions	AECOM Field Manager	Dunn Henry	404-965-9703	The AECOM field manager will have the authority to stop work and issue corrective response actions to field sampling personnel. Modes of communications will be by telephone or email within 24 hours.
Daily chain of custody (CoC) reports and shipping documentation	AECOM Field QC Coordinator	Randy Morgan	864.423.2105	CoCs and shipping records will be submitted via fax or email to the AECOM project chemist at the end of each day that samples are collected.
Daily Safety Meetings	AECOM Site Safety & Health Plan Officer	Randy Morgan	864.423.2105	The AECOM site safety and health officer will oversee daily site safety and health, ensure daily tailgate safety meetings are conducted, have the authority to stop work and report any incidents or near misses to the AECOM PM.
Sample Receipt Variances	GCAL Project Manager	Kimberly Drag	225.769.4900	All variances in sample receipt will be reported to the AECOM project chemist by the laboratory within 24 hours of variance. A signed copy of the CoCs and a completed Sample Condition Report will be provided to the project chemist within 24 hours of sample receipt.
Reporting laboratory data quality issues	GCAL Project Manager	Kimberly Drag	225.769.4900	Sample-specific QA/QC issues that potentially affect data usability will be reported by the laboratory project manager to the AECOM project chemist by e-mail within 1 business day.
Reporting Lab Quality Variances	GCAL Project Manager	Kimberly Drag	225.769.4900	All laboratory QA/QC variance issues will be reported to AECOM project chemist by the laboratory project manager within 1 day of variance. The variance(s) will be reported to the AECOM PM the same business day and to the USACE within 2 business days.
Analytical Corrective Actions	AECOM Project Chemist	Dwight Parks	303.740.3811	The AECOM project chemist will immediately notify the AECOM PM and the laboratory project manager by email of field or analytical procedures that were not performed in accordance with the planning documents. The AECOM project chemist will document the non-conformance, issue the corrective actions to be taken, and verify implementation of the corrective actions by the laboratory.
Data Validation Corrective Actions	AECOM Project Chemist	Dwight Parks	303.740.3811	The AECOM project chemist will have the authority to issue corrective response actions to laboratory and data validation firms. Corrective actions may be issued to the laboratory as a result of data validation results. Modes of communications will be by telephone or e-mail within 24 hours after audit.

WORKSHEET #7: PERSONNEL RESPONSIBILITIES TABLE

Title	Name	Phone Number Email Address	Responsibilities
ADEM			
ADEM, Remediation Project Manager	Colin Mitchell	Phone: 334.271.7730 Email: cjmitchell@adem.state.al.us	Compliance with Alabama Department of Environmental Management (ADEM) Regulations
USACE			
Contracting Officer's Representative	Melissa Shirley	251-690-2616 Melissa.L.Shirley@usace.army.mil	Compliance with contract task order performance work statement
Assistant COR	Linda Bookout	251-694-4056 linda.l.bookout@usace.army.mil	Provides technical and engineering support.
ARNG			
ARNG-ILE Clean Up	Brett Merkel	703-601-7785 brett.a.merkel.civ@mail.mil	Project Sponsor and project acceptance of work and document submittals
ALARNG			
Compliance Manager	Sheri M. Festoso, PE	334-271-8183 sheri.m.festoso.nfg@mail.mil	Alabama ARNG Environmental Compliance Chief
ALARNG OMS#28			
Chief, Field Maintenance Shop (FMS) #28	Chief Thomas Gibbs	251-405-4922 / 251-405-4926 334-558-1113 (m)	Chief for FMS #28 (formerly OMS#28)
Assistant Shop Supervisor	Chief Karl Trawic	251-405-4922 / 251-405-4926 251-554-1900 (m)	Assistant Shop Supervisor for FMS#28
AECOM			
Program Manager	Manish Joshi	210-253-7509 Manish.Joshi@aecom.com	National Guard Bureau Program Lead which ensures compliance with contractual documents and participates in performance discussions with USACE and ARNG to ensure client satisfaction.
Project Manager	Steve Holt	864-234-2260 404-317-4101 (m) Steve.Holt@aecom.com	Provides overall project management to include resource allocation, procurement, project controls, risk management, health and safety, quality, and financial considerations; serves as primary point of contact; provides final internal review of all technical plans and reports.

Title	Name	Phone Number Email Address	Responsibilities
Licensed Alabama Geologist	Dunn Henry	404-965-9703 Dunn.Henry@aecom.com	Technical advisor and review of all documents requiring Alabama license geologist seal.
Task Manager	Vasi Kourlas	864-234-3038 Vasi.Kourlas@aecom.com	Assign field work resources, coordinate project schedule and draft project deliverables.
Laboratory			
GCAL, Project Manager	Kimberly Drag	225-769-4900 kimberly.drag@gcal.com	Off-Site Fixed Laboratory; Regional Account Manager
Columbia Technology	John Sohl	888-344-2704 ext 201 jsohl@columbiatechnologies.com	On-Site Mobile Laboratory
Land Clearing			
Landshark Hauling and Clearing, LLC	Jon Taulbee	251.621.0668 Landshark256@bellsouth.net	Land clearing and hauling subcontractor
Drilling			
TBD			

WORKSHEET #8: SPECIAL PERSONNEL TRAINING REQUIREMENTS TABLE

All personnel who will access the site shall comply with applicable installation, facility and area commander installation/facility access and local security policies and procedures (provided by government representative). Prior to the beginning of any onsite work, anyone who will access the site will be required to provide information required for background checks to meet installation access requirements to be accomplished by installation Provost Marshal Office, Director of Emergency Services or Security Office.

Several anti-terrorist trainings are required prior to accessing the site; Anti-Terrorist AT Level 1 training and iWatch Training.

Anti-Terrorist Level 1: All personnel will need to complete the Anti-Terrorist Level 1 awareness training prior to accessing the site. A certificate of completion for each person accessing (AECOM personnel and subcontractors) the site will be sent to the AECOM Project Manager who will send the certificates to the USACE Mobile COR. Anti-Terrorist level I awareness training is available at the following website: http://jko.jten.mil.

iWatch Training: AECOM will brief all employees and subcontractors on the local iWatch program through PowerPoint slides provided to AECOM by the USACE Mobile COR. A signature page will be generated by the AECOM Project Managers acknowledging completions of the iWatch program and provided to the USACE Mobile COR.

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WORKSHEET #9: PROJECT SCOPING SESSION PARTICIPANTS SHEET

Project Name: Project Kick-Off Meeting
Projected Date: 12 November 2015
Project Manager: Steve Holt

Site Name: ALARNG OMS #28
Site Location: Mobile, AL

Date of Session: 12 November 2015

Scoping Session Purpose: Kick Off Meeting with ADEM and preview field investigation work plan (WP) prepared in the UFP-QAPP

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Brandi Little		ADEM	334.274.4226	BLittle@adem.state.al.us	N/A
Kaneshia Townsend		ADEM	Not provided	KTownsend@adem.state.al.us	N/A
Julie Ange		ADEM	334.270.5046	JAnge@adem.state.al.us	N/A
Colin Mitchell		ADEM	334.271.7967	CJMitchell@adem.state.al.us	OMS #28 Regulator
Ashley Mastin		ADEM	334.271.7797	ATMastin@adem.state.al.us	N/A
Lee Thomas		ADEM	334.394.4371	NLT@adem.state.al.us	N/A
Brett Merkel	ARNG-ILE Clean Up	ARNG	703.601.7785	Brett.a.merkel.civ@mail.mil	ARNG Program Manager
Sheri Festoso	ALARNG Compliance Manager	ALARNG	334.271.8183	Sheri.m.festoso.nfg@mail.mil	ALARNG Compliance Manager
Karen Pinson	FM-ARNGTC Restoration	Fort McClellan	256.847.4592	Karen.b.pinson.ctr@mail.mil	N/A
Melissa Shirley	CESAM-EN-GE	USACE	251.690.2616	Melissa.l.shirley@usace.army.mil	USACE SAM Project Manager
Linda Bookout		USACE	251.694.4056	Linda.L.Bookout@usace.army.mil	USACE SAM Technical Manager
Steve Holt	Project Manager	AECOM	864.234.2260	Steve.holt@aecom.com	AECOM Project Manager
Alex Eddington		AECOM	850.269.2200 x20	Alex.Eddington@aecom.com	N/A
Steve Duda		AECOM	864.234.3595	Steve.duda@aecom.com	N/A
Vasi Kourlas	Task Manager	AECOM	864.234.3038	Vasi.kourlas@aecom.com	Task Manager
Adam Balogh		TRC			Regulator Subconsultant
Katarina Rautkowski		TRC			Regulator Subconsultant
Scott Hime		TRC			Regulator Subconsultant

Comments/Decisions:

1. AECOM presented the status of the work plan for the ALARNG OMS #28 in Mobile Alabama.

2. USACE has Mobile Airport Authority (MAA) master plan for area west of OMS for risk assessment.

3. Concern over vapor intrusion for residence north of OMS #28. Need to add a well north of OMS-28-3 towards residence for soil gas (Gore Absorber) or Summa canister in basement.

Action Items:

USACE to submit MAA master plan to AECOM – AECOM received master plan from USACE on 16 Nov 2015

Consensus Decisions:

3. Concern over vapor intrusion for residence north of OMS #28. Need to add a well north of OMS-28-3 towards residence for soil gas (Gore Absorber) or Summa canister in basement.

WORKSHEET #10: CONCEPTUAL SITE MODEL

10.1 Site Description

OMS #28 is located in Mobile County, near downtown Mobile at 1622 South Broad Street, between U.S. Interstate Highway 10 (I-10) and Mobile Bay (**Figure 1**). The property is relatively flat with an elevation of approximately 20 to 30 feet above mean sea level (MSL). The OMS #28 site is bordered by undeveloped land and I-10 to the west; residential property to the north, Fort Floyd A. McCorkle ALARNG facility building to the east; and Farmer Fresh Produce, Masonite, Inc., and SpillTech, Inc. to the south. The surface features consist of vegetative cover comprised of oak trees, scrub trees, grasses, and brush. The nearest residential structure is approximately 150 feet northeast of the OMS #28 building.

OMS #28 is located in the northwest corner of the former Brookley Air Force Base (AFB). The former AFB is now the Brookley Aeroplex. The initial 1,000 acres were acquired by the DoD in 1938 with additional land acquisitions through 1955 for a total of 3,156 acres. Brookley AFB was operated by the Air Force as a general support and supply base until June 1969 when it was officially closed. DoD returned Brookley AFB to the city of Mobile and the city created the MAA in 1972. Facilities at the Brookley Aeroplax include runways and maintenance areas for aircraft, underground and aboveground fuel storage facilities, associated buildings, roads, housing and landfills. No human consumption or agricultural wells are located within the boundaries of the Brookley Aeroplex. The Brookley Aeroplex is currently used as an industrial complex and airport by the MAA (Scientific Applications International Corporation [SAIC], May 2013).

Currently, the Alabama Armory Commission owns the 5.9 acres of property on which OMS #28 is located, and ALARNG operates the FMS (formerly known as the OMS). The Alabama Armory Commission has owned this property since 1953 when the City of Mobile conveyed 25.66 acres to the Commission. In 2002, 6.43 acres west of the OMS #28 property reverted back to the City and the City subsequently conveyed the property to the MAA (SAIC, May 2013).

It should be noted that the ALARNG renamed OMS #28 to FMS #28 several years ago; however, the Site is referred to as OMS #28 in all previous ALARNG, ADEM, and USACE investigation reports; therefore, to avoid confusion, the Site is referred to herein as OMS #28. According to ALARNG personnel, Site operations have not significantly changed since conversion to FMS #28 (Louis Berger, 2015).

10.2 Site Background and History

The Site has undergone numerous development, redevelopment, and organizational periods since initial development. The original/former OMS #28 building was constructed in the early 1950s and the original OMS #29 building was constructed in the 1960's. The current OMS #28 building was constructed in 1978 and operations were transferred from the old/original building. The original/former OMS #28 building was used for storage from 1978 until demolition in 2001. Operations within OMS #29 were also transferred to the new OMS #28 building and the old OMS #29 building was used for storage and eventually demolished. The OMS #28 building was expanded in 1994 to accommodate a greater volume of work. Currently, the OMS #28 building is used for vehicle staging and maintenance and direct support for military police, medical, signal, communications, and field artillery units (Louis Berger, 2015).

A wash pad was formerly operational in the far northwestern corner of the parking lot until 1978. The wash pad was constructed as a concrete slab with no drainage system in place. Military vehicles were routinely washed in this area and wash water was allowed to flow freely onto the ground.

Four underground storage units (USTs) were removed from three separate locations (i.e., Pit 1, Pit 2, and Pit 3) at the Site in October 1992. Upon removal of a single 2,000-gallon gas/diesel UST at Pit 2, petroleum-related soil and groundwater contamination was identified; however, a preliminary sampling effort was unable to determine the nature and extent of the contaminants. Additional investigation in December 1994 reportedly completely delineated the extent of petroleum-related soil and groundwater contamination associated with Pit 2. Quarterly groundwater monitoring for petroleum-related contaminants began in 1995 and continued through 2004. Further Site characterization was deemed necessary and was performed in 2004 and 2005 when analysis of quarterly groundwater sampling results indicated that petroleum contamination had migrated beyond the original monitoring well network installed during the initial 1994 groundwater investigation. This supplemental work consisted of the installation of additional monitoring wells at the Site, in another attempt to delineate petroleum contamination associated with Pit 2 (Louis Berger, 2015). **Figure 2** shows the investigation area and relevant historical features.

In August 2005, trichloroethene (TCE) was detected at the Site for the first time in monitoring well MW-8. The presence of TCE in MW-8 was determined to be unrelated to the petroleum tanks that were removed from the Site in 1992; however, the source of TCE was unknown. In April 2007, TCE-contaminated soil was observed in discrete potential source areas within the TCE, and later tetrachloroethene (PCE), plumes (**Figure 2**). Installation and sampling of additional monitoring wells in November 2008 achieved delineation of the horizontal and vertical extents of TCE and PCE groundwater contamination at the Site (**Figure 3**) (Louis Berger, 2015).

Historically, TCE was documented as high as 11 micrograms per liter (µg/L) at off-site monitoring well MW-10 and 63 µg/L at MW-11 in 2006. These monitoring wells were installed northwest of the Site, on private residential property. Monitoring wells MW-10 and MW-11 were subsequently abandoned in 2008 at the property owner’s request and have not been replaced (Louis Berger, 2015). Based on analysis of the most current groundwater data (2010), the apparent groundwater flow direction does not appear to indicate that the plume is or would impact the residential properties to the north of the OMS #28 building. These residential properties are side and/or up gradient of the source and groundwater flow direction.

Groundwater compliance monitoring was conducted at the Site in December 2008, May 2009, September 2009, March 2010, and September 2010 at monitoring wells MW-5, MW-6, MW-8, MW-9, MW-12, and OMS-28-1 through OMS-28-7. The monitoring effort was implemented to document and monitor groundwater conditions at the Site (Louis Berger, 2015).

Based on the extensive investigative work completed to date, the potential source area for the TCE plume appears to be in the vicinity of monitoring well MW-8, which corresponds with the largest suspected area of residual soil contamination. Monitoring well MW-8 is located near the former wash pad along the westernmost Site boundary, in an area where military vehicles and equipment are currently stored. PCE groundwater contamination appears to be limited to the area surrounding monitoring well OMS-28-5, which is located within a densely wooded area west of the Site. It was noted during a site reconnaissance performed by Louis Berger in 2015 that in the 1960's and 1970's "Gunk" Energized Electric Motor Contact Cleaner was used as a cleaning agent. According to a retired ALARNG employee, "Gunk" was used during the same time period as the wash pad; however, there is no official record of "Gunk" being used in the vicinity of the wash pad (Louis Berger, 2015). According to Material Safety Data Sheets, "Gunk" cleaners may contain up to 90-100% PCE.

Initially, the OMS #28 chlorinated solvents plume was following a Resource Conservation and Recovery Act cleanup path due to the actions required following the discovery of TCE under the UST regulatory requirements. In September 2010, ALARNG submitted a request to ADEM to continue the activities at the site under the CERCLA. At the time, ALARNG was in the process of having an ARBCA Report prepared and recommended using the existing data to develop a Remedial Investigation (RI)/Feasibility Study (FS). ADEM concurred with this approach in e-mail correspondence dated September 9, 2010 (ADEM, 2010a).

10.3 Previous Investigations

The original investigations centered on the contamination associated with the UST located at Pit 2. The UST-related investigations that have been performed at OMS #28 are summarized in the RI (SAIC, 2013). ADEM determined that no further subsurface investigation was required for the UST located at Pit 2 (correspondence dated January 19, 2007, from the ADEM UST Corrective Action Section [ADEM, 2007]). The chlorinated solvents-related investigations performed following the discovery of TCE in MW-8 in 2005 were documented in the following reports:

- TCE Comprehensive Investigation at OMS-28 (Aerostar, 2007).
- Supplemental Comprehensive Investigation Report for OMS-28 (Aerostar, 2008a).
- Supplemental Comprehensive Investigation Groundwater Monitoring Reports for OMS-28 (Aerostar 2009a, 2009b, 2009c, 2010, and 2011a).
- Alabama Risk-Based Corrective Action Report for OMS-28 (Aerostar, 2011b).
- RI (USACE, 2011; Revision 1 SAIC, 2012; Revision 2 SAIC, 2013).
- FS (Leidos, 2014).
- Historical Research Study Report (Louis Berger, 2015).

10.4 Current Land Use

The current land use is based on a site reconnaissance performed by Louis Berger on March 31, 2015 and April 30, 2015 (Louis Berger, 2015). The Site is developed with the OMS #28 building and several other smaller storage buildings. The ancillary storage buildings contained items such as miscellaneous wood items, fans, vehicle ramps, fire extinguishers, and miscellaneous metal. Each storage building is constructed as slab-on-grade. There was no staining or other evidence of release observed in these buildings. No operations, other than storage, are performed in these buildings.

The majority of the Site is developed with concrete-paved driveways and vehicle storage areas. Some areas of the Site are unpaved and used for vehicle storage. Numerous military vehicles were stored at the Site at the time of the visit. Drip pans were present beneath nearly all of the vehicles (Louis Berger, 2015).

The majority of the OMS #28 building consists of five vehicle bays (10 total work spaces) where routine maintenance on military vehicles is performed. The remainder of the building consists of office space and a break room. Servicing of military vehicles includes fluid changes and routine inspections to ensure safety and functionality. Waste oil generated in the work bays is deposited into one of two waste oil above ground storage tanks along the north side of the building. Other waste vehicle fluids are containerized in 5- or 55-gallon drums and stored in a designated “Hazardous Materials Storage Area” or “Petroleum Products Storage Area” until pick-up and off-site disposal by an outside contractor on an as-needed basis. These storage areas appeared well-maintained, clean, and were equipped with secondary containment systems for spills (Louis Berger, 2015).

Two vehicle wash racks are present at the Site and are connected to a single oil/water separator. One wash rack is located north of the OMS #28 building and the other is located west of the building. According to onsite personnel, the northern wash rack is rarely used because the drain easily clogs. The western wash rack is equipped with a large hydraulic oil lift system capable of lifting large/heavy military vehicles. A trench drain at this rack drains into an underground cistern where the oil and water mixture separates.

A concrete pad measuring approximately 50 feet wide by 50 feet long was observed in the wooded area approximately 50 feet west of the OMS #28 complex fence-line (**Figure 2**) during the 2015 reconnaissance by Louis Berger. The concrete pad comprised of six distinct and individual strips of concrete spaced a few inches apart. The concrete pad corresponds to the approximate former location of Mollison Hall, a recreational hall for soldiers, and is possibly a building foundation remnant.

10.5 Physiography and Topography

The Brookley Aeroplex is located within Mobile County. Much of the land in Mobile County is used for industrial and agricultural purposes. Large areas along the Mobile and Tensaw Rivers and along the coast are characterized by low-lying, swampy terrain and brackish water. The Brookley Aeroplex is included in this area (SAIC, 2013).

The Brookley Aeroplex lies entirely within the East Gulf Coastal Plain physiographic section, Alluvial-Deltaic Plain District, Coastal Lowlands District. The Alluvial-Deltaic Plain District, which consists of alluvial and terrace deposits from the rivers, has areas with very little relief and the surface topography ranges in altitude from 100 feet to sea level (SAIC, 2013).

Coastal Lowlands District areas are characterized by flat to gently undulating, locally swampy plains underlain by terrigenous deposits of Holocene and late Pleistocene age. They include the mainland plain indented by many tidal streams and fringed by tidal marshes and barrier islands. The landward edge of the district is defined by the base of the Pamlico marine scarp at 25 to 30 feet of elevation. The barrier islands and tidal marshes in the area are undergoing continual modification by erosion and deposition (SAIC, 2013).

The Brookley Aeroplex is relatively flat with an elevation of 20 to 30 feet above MSL (Aerostar 2011b). OMS #28 is located in the northeast corner of the Brookley Aeroplex where the elevations are closer to 30 feet above MSL (SAIC, 2013).

10.6 Hydrology

According to the Brookley AFB RI Report (Kevric, 2004), the Brookley Aeroplex is part of the Mobile Bay Watershed. The fluvial drainage area of this watershed encompasses nearly two-thirds of the state of Alabama and crosses into Georgia, Mississippi, and Tennessee. This coastal lowlands aquifer system, according to the EPA State Health Evaluation (USEPA, 1999), has an Index Watershed Indicator of "Less Serious Water Quality Problems (Low Vulnerability to Stressors such as Pollutant Loading)." Furthermore, ADEM's 2010 Alabama Unified Watershed Assessment classified parts of Mobile Bay as Category 1 – "waters that are attaining all applicable water quality standards" or Category 5 – "waters in which a pollutant has caused or is suspected of causing impairment" (ADEM, 2010b). The Category 1 classification was associated with Mobile County. The Baldwin County portion of Mobile Bay received the Category 5 classification (SAIC, 2013).

Surface flow from storm water runoff across the site varies due to surface grade, vegetation, and porous surface medium (SAIC, 2013). During the site reconnaissance in 2015 of the wooded property west of the site (MAA property), standing water and a drainage ditch which ultimately flowed away from the site to the west toward the rail road tracks was observed. While standing water was observed in some areas, a strong flow was observed in the area of the rail road tracks. A small potential ditch was observed running west away from the former wash pad, ultimately connecting to the area of standing water. No pipes or drains were observed during the reconnaissance (Louis Berger, 2015).

Based on a site visit conducted in September of 2015; it appears that there could be a surface water feature on the MAA property, west of the site. This property was not able to be accessed during the site visit, however upon clearing this area (prior to investigative activities); an assessment of potential water body will be documented and added to the site conceptual model. Should it be determined that a permanent surface water body exists within this property, an evaluation will be conducted as to whether contamination from the site (via overland flow or groundwater discharge) will be able to contact this potential water body.

10.7 Site Geology

Geologic units that occur within the study area range in age from Tertiary to Quaternary. Alluvial and terrace deposits of Quaternary age overlie Tertiary-age deposits adjacent to the floodplains of the larger streams and river and along the coastal areas, such as Mobile Bay (SAIC, 2013).

Geologic units of Tertiary age that are sources of potable groundwater are the Miocene Series Undifferentiated and the Citronelle Formation. The Miocene Series outcrops in central and northern Mobile and Baldwin Counties. The Miocene Series consists of sedimentary deposits of marine and estuarine origin. The sediment consists mainly of laminated to thinly bedded clays, sands, and sandy clays. The sands range from fine- to coarse-grained and are locally cross-bedded. In outcrops, the sands weather to a variety of colors, some distinctly mottled. At some exposures, beds of sand contain gravel and petrified plant fossils and clays contain carbonized leaf remains (SAIC, 2013).

The Citronelle Formation of Pliocene age overlies the Miocene Series and crops out in central and southern parts of the RI study area. The formation, which is relatively thin in northern parts of the study area, is about 200 feet thick in the subsurface in the southern part of the study area. The sediment consists of gravelly sands and sandy clays. In many areas, lenses of sandy clay and clayey sand, which range in thickness from 5 to 15 feet, are interbedded with gravelly sand. Sediment along the base of the Citronelle Formation has a high clay content, indicating that it was deposited in an estuarine environment; whereas, overlying sediment was deposited by sediment-laden streams (SAIC, 2013).

Pleistocene and Holocene Series of Quaternary age deposits overlie Miocene and Pliocene sediment. Alluvial, low terrace, and coastal deposits represent complex beach, dune, lagoon, estuarine, and deltaic depositional environments. The deposits consist of very fine- to coarse-grained sand that is gravelly in many exposures. Sandy clay is interbedded with the sand at some exposures. The thickness of the alluvial, low terrace, and coastal deposits is estimated to range from 0 to 200 feet based on the first occurrence of coarse siliclastic sediment (SAIC, 2013).

The Quaternary sand and gravel beds represent buried channel deposits. Their width and depth are similar to that of the present river bed sediment. The length of individual sand and gravel beds probably ranges from a few hundred to a few thousand feet. These buried channel deposits are surrounded by silt and clay sediment similar to that being deposited on the present floodplain of the river (SAIC, 2013).

According to the Supplemental Comprehensive Investigation Report for OMS #28 (Aerostar, 2008a), the general site geology with some exceptions was as follows:

- Ground surface to approximately 5 feet below ground surface (bgs) was a silty clay loam.
- Beginning at approximately 5 feet bgs, medium-grained sands, silty sands, and clayey sands were encountered in various borings.
- Beginning at depths ranging between 16 and 35 feet bgs, a gray stiff clay was encountered, which continued to a depth of 70 to 84 feet bgs.
- At depths ranging between 70 and 84 feet bgs, coarse-grained sand was encountered. In the exploratory boring, the coarse-grained sand ended at 90 feet bgs where clayey sand extended to a depth of 104 feet bgs. Sandy clay and silty clay were encountered from 104 feet bgs to boring termination depth at 120 feet bgs.

10.8 Site Hydrogeology

The Pliocene-Miocene aquifer and the alluvial-coastal aquifer are the major at the former Brookley AFB. Although the aquifers are lithologically different, they are hydraulically connected and generally respond to stresses as a single aquifer. Groundwater in the Pliocene-Miocene aquifer occurs in beds of sand and gravel that are lenticular in shape and of limited lateral extent. The sand and gravel beds in the Citronelle Formation and those at shallow depths in the Miocene Series Undifferentiated are hydraulically connected to land surface; therefore, the aquifer is unconfined. At depth, clayey sediment in the Miocene Series is semi-confining, which reduces vertical infiltration of water. Thus, the aquifer in deeper portions of the Miocene Series responds to short-term pumping as a confined aquifer. Wells properly constructed in the Pliocene-Miocene aquifer yield from 0.5 to 2.0 million gallons per day (Mgal/day) (SAIC, 2013).

The alluvial-coastal aquifer is hydraulically connected to the Pliocene-Miocene aquifer. Properly constructed wells in the alluvial-coastal aquifer have the potential to yield from 0.5 to 1.0 Mgal/day. Most high-yield wells are completed in beds of sand and gravel that originate from coastal deposits and buried river sediment. The buried channels are surrounded by silty and clayey sediment that does not yield significant amounts of water but does allow slow infiltration of water to the sand and gravel beds. Individual buried channels may be directly connected to the present channels of the Mobile River (SAIC, 2013).

The source of recharge to the aquifers is rainfall, which averages 62 inches per year (in/yr) in the study area. About 28 in/yr of rainfall runs off during and immediately after storms, a small amount of rainfall infiltrates the subsurface as recharge to the aquifers, and the remainder is returned to the atmosphere by evaporation and transpiration of trees and other plants (SAIC, 2013).

Groundwater discharges are primarily to streams, water bodies, and wells. Some of the larger groundwater pumping centers in the study area are the cities of Grand Bay, Fairview, Dauphin Island, Theodore, Kushla, LeMoyne, Citronelle, Mt. Vernon, Bayou La Batre, Saraland, and St. Elmo in Mobile County (SAIC, 2013).

Depth to groundwater was last measured at the site on September 8, 2010. The groundwater elevations in the shallow wells ranged from 19.35 feet to 23.78 feet referenced to national geodetic vertical datum MSL. The calculated groundwater elevations in the deep wells ranged from 1.96 feet to 4.21 feet MSL. Based on the groundwater elevations collected from the shallow aquifer zone, the apparent groundwater flow direction is northwest.

10.9 Ecology

As of April 2012, the U.S. Fish and Wildlife has listed several species of concern (candidate, recovery, endangered, or, threatened) that are known or are believed to occur in Mobile County, which include the bald eagle, wood stork, piping plover, gulf sturgeon, West Indian manatee, hawksbill sea turtle, leatherback sea turtle, kemp's ridley sea turtle, green sea turtle, loggerhead sea turtle, Alabama red-belly turtle, eastern indigo snake, black pine snake, and gopher tortoise (SAIC, 2013).

Critical habitats for the piping plover, gulf sturgeon, West Indian manatee, hawksbill sea turtle, leatherback sea turtle, and green sea turtle are located at the mouth of Mobile Bay and not located within 2 miles of Brookley Aeroplex. No known ecological survey has been conducted at the Brookley Aeroplex since the ecological reconnaissance conducted as part of the Former Brookley AFB RI activities in the early 2000s. According to the U.S. Fish and Wildlife, no threatened or endangered species have been reported or confirmed on the property. The gopher tortoise, which is an upland species, is scattered in small numbers across Mobile County and may be present on or near the site (SAIC, 2013).

At OMS #28, the surface features consist of vegetative cover comprised of oak trees, scrub trees, grasses, and brush (Aerostar 2011b). No permanent structures are present on the portion of the Site where the groundwater plume has been identified. The current OMS #28 building is located approximately 250 feet east of the groundwater plume. The nearest residential structure is approximately 150 feet northeast of the OMS #28 building.

WORKSHEET #11: PROJECT QUALITY OBJECTIVES/SYSTEMATIC PLANNING PROCESS STATEMENTS

Worksheet #11 provides the Project Quality Objectives (PQOs) which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the investigation. PQOs were developed using a seven-step process based on the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA QA/G-4) (USEPA, 2006). The systematic planning process is an evaluation tool used to identify the problems and the goals of the study and the steps required to make appropriate decisions. The seven-steps are identified and described as follows:

1. State the Problem – Defines the problem that initiated the study.
2. Identify the Goal of the Study – Identifies the key question that the study attempts to address.
3. Identify the Information Inputs to the Decision – Identifies sources of information needed to resolve the decision statement.
4. Define the Boundaries of the Study – Identifies potential receptors or specifies the spatial and temporal features or boundaries pertinent to the decision making process.
5. Develop the Analytic Approach – Development of an analytical design that identifies conclusions reached based on an evaluation of the study results.
6. Specify Performance or Acceptance Criteria – Identifies the criteria established to prevent potential erroneous decisions by minimizing the uncertainty of inputs to the decision making process to acceptable levels.
7. Develop the Plan for Obtaining Data – Development of a resource-effective design for collecting and measuring environmental samples, or for generating other types of information needed to address the problem statement.

11.1 Project Quality Objectives

PQOs were developed to facilitate the development of the sampling and analysis program, which will be implemented to fill data gaps and refine the plume boundary. The seven PQO steps are presented in a tabular format in Table 11-1.

11.2 Total Study Error

Total study error should be managed to the extent practical so that decision makers can be confident that the data collected from the implementation of the field investigation is representative of the site. The field investigation will be designed based on an evaluation of available data to minimize total study error. The investigation will utilize decision error minimization techniques for reducing sampling and measurement error. The following sections discuss the methods proposed to reduce sampling and measurement errors.

11.2.1 Managing Sampling Error

Potential decision errors will be minimized by controlling sampling error to the extent practical. Sampling error will be controlled by conducting the proposed field investigation in accordance with relevant standard operating procedures (SOPs) (Worksheet #21), acquiring an appropriate number of QA/QC samples (Worksheet #12 and #20), and calibrating, maintaining, testing, and inspecting field equipment (Worksheets #20, #21, and #22).

11.2.2 Managing Measurement Error

Potential decision errors will be minimized by controlling laboratory measurement error to the extent practical. Laboratory sampling error may be introduced during preparation and analysis of discrete samples. Laboratory measurement errors will be controlled by following standard analytical procedures and methods, evaluating QA/QC data, and calibrating, maintaining, testing, and inspecting laboratory equipment (Worksheets #23, #24, #25). An analytical laboratory certified by the DoD Environmental Laboratory Accreditation Program (ELAP) will analyze samples using appropriate analytical methods (discussed in Worksheets #23, #24, #25), and qualified laboratory technicians will operate laboratory instruments to reduce measurement errors (off-site, fixed based laboratory).

Table 11.1: Project Quality Objectives

Data Quality Objective (DQO) Step	Description
1. State the Problem	Past maintenance operations from the former OMS #28 Site have resulted in petroleum and solvent contamination releases to soil and groundwater. PCE and TCE contamination remain in the soil and groundwater west of the OMS #28 building based on previous investigations. An expanded remedial investigation will be conducted to further delineate soil and groundwater contamination.
2. Identify the Goals of the Study (Alternative Actions presented in Step 5)	The Supplemental Data Gap Investigation will be performed to address potential data gaps, refine the groundwater plume boundary in order to reduce the area needed for remediation, and determine if any addition soil sources are present which may be contributing to the groundwater contamination. This information will be utilized to conduct a human health and screening level ecological risk assessment. This information will in turn provide the based for re-evaluation of the existing FS to determine if the proposed remediation alternative is the proper choice based on new data.
3. Identify Information Inputs	• Several investigations have been conducted at OMS #28. These investigations are documented in Worksheet #13 and Administrative Records website for OMS #28 at: http://www.mobileoms28.net/ oms28/Website%20Admin%20Record/OMS-28-Admin-Record-Index.pdf. The types of information and measurements that need to be collected in order to answer environmental remedial questions and make informed risk management decisions regarding this site include, but are not limited to, the following: • Observations of the site conditions (e.g., odor, discolored soil, stressed vegetation) indicating exposed waste or impacted soil; • Observations of geologic conditions in the subsurface, made during intrusive investigation activities (e.g., drilling of boreholes for soil and groundwater sampling, and low level membrane interface probe (LLMIP)/hydraulic profiling tool (HPT) data); • Depth-to-groundwater measurements from monitoring wells for the evaluation of groundwater flow direction; • Discrete surface soil (0.0 to 1.0 foot bgs), subsurface soil (below 1.0 foot bgs), and groundwater samples submitted for analyses of PCE and TCE by the mobile, on-site laboratory and for Target Compound List (TCL) volatile organic compounds (VOCs) by the fixed, off-site laboratory; • Field parameter measurements collected during groundwater sampling, such as potential hydrogen ion (pH), specific conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential, salinity, and turbidity; • Sample depths and surveyed location coordinates for all samples collected; • QA/QC data, including field duplicates, slips, trip blanks, matrix spike/matrix spike duplicates (MS/MSDs), and data validation results.

Data Quality Objective (DQO) Step	Description
4. Define the Boundaries of the Study	**Lateral Boundary:** As discussed in Worksheet #10 the currently established location and associated boundary of the site are based on previous site investigations. The approximate site boundary is shown on **Figure 2**. **Vertical Boundary:** The vertical boundary of the study area is approximately 35 feet or to the top of the clay confining layer. There are three monitoring wells screened below the clay confining layer (deep wells) which have not shown concentrations of VOCs above any screening criteria. Therefore, the groundwater investigation portion is limited to the aquifer unit above the confining clay layer. **Temporal Boundary:** The estimated project duration is two years. **Other Boundaries:** Potential receptors shall include hypothetical future residents, industrial workers, excavation/construction workers, maintenance workers, and trespassers.
5. Develop the Analytic Approach	Decisions made during this investigation will be based on the field data, quantitative analytical data, and subsequent data evaluation. Analytical data that meets DQOs will then be used to guide the iterative data review and decision making process of subsequent mobilizations. It will also be used to assess whether contaminant concentrations pose a potential risk to current and future human and ecological receptors. These results will be used to provide input to the remedial decision making process. A phased approach of iterative data collection and review is proposed. Based on this approach, the following decision rules ("If/Then" statements) have been developed for this project. Work Implementation Process Evaluation • If groundwater samples collected during the first mobilization indicate significantly higher concentrations of historically detected chemicals of concern (COCs) or high concentrations of newly identified analytes, increasing the uncertainty of the level of understanding currently expressed in the conceptual site model (CSM), then additional targeted exploration and sampling may be conducted to characterize and define potential sources. • If calculated groundwater elevations derived from the expanded monitoring well network result in a more accurate understanding of groundwater flow directions, then the expanded monitoring well network will be evaluated to determine if additional monitoring wells will be necessary to adequately monitor any site-related groundwater contamination. • If groundwater samples collected from the proposed locations indicate that COCs are present within lower portions of the surficial aquifer, then additional groundwater sampling will be conducted to define the deeper groundwater impacts including the installation of deeper monitoring wells, if warranted. Conversely, if COCs are not identified within deeper portions of the residuum aquifer in deep monitoring wells, then the installation of deep monitoring wells or deeper investigation of the bedrock aquifer will not be performed. Data Evaluation Process Evaluation • The following if/then statements apply to the data evaluation with respect to the project-specific DQO screening criteria provided in Worksheet #15: • If analytical data are below DQOs, then those constituents will not be identified as COCs and no further investigation is

Data Quality Objective (DQO) Step	Description
	warranted for those constituents. • If analytical data are above DQOs, then those constituents will be assessed for human health and ecological risk during the Baseline Risk Assessment (BRA) to identify final human health and ecological COCs/chemicals of potential ecologic concern for the FS.
6. Specify Performance or Acceptance Criteria	Analytical data from all phases of the sampling conducted in support of this Supplemental Data Gap Investigation will be generated by either a mobile or a fixed-base laboratory from discrete media samples and validated in accordance with the data validation procedures discussed in Worksheets #34, #35, and #36. The quality of the data collected during this Supplemental Data Gap Investigation must be adequate to determine the risks to current and future human and ecological receptors, and the development and detailed analysis to evaluate the remedial alternative previously developed in the FS. • A sufficient quantity of QA/QC samples will be collected to evaluate the quality of the data. • Field and laboratory tasks will be performed in accordance with approved field and analytical SOPs. • Risks within the USEPA risk management range of 10^{-4} to 10^{-6} will be considered acceptable. • A sufficient quantity of samples will be collected to have confidence in the data set. • For sampling and analytical tasks, erroneous decisions can be attributed to sampling error and/or measurement error. Sampling error occurs when the design and implementation of the field sampling plan does not provide representative data for the site. Measurement error occurs as a result of performance variance from laboratory instrumentation, analytical methods, and operator error. The USEPA identifies the combination of all these errors as a “total study error” (USEPA, 2006). A discussion of total study error is presented in Section 11.2
7. Develop the Plan for Obtaining Data	Soil and groundwater samples will be collected and analyzed, and the resulting data will be evaluated to refine the delineation of contamination. The investigation will be conducted in a phased approach. Two rounds of groundwater monitoring will be implemented. During the first round, groundwater samples will be collected and analyzed to describe current conditions. A phased approach will be used to further delineate groundwater and identify any potential soil sources. LLMIP will be used to identify sources in soil and higher groundwater contaminant concentrations, specifically at depths below the shallow groundwater wells screens to the top of the confining clay layer. Soil and groundwater samples will be collected to confirm the LLMIP results and refine the delineation of the contamination and analyzed by the mobile, on-site laboratory for PCE and TCE and used to identify locations potentially free of contamination as well as locations that are potentially contaminated. Confirmatory samples (split samples) will be sent to a fixed, off-site laboratory and analyzed for TCL VOCs.

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WORKSHEET #12: FIELD QUALITY CONTROL SAMPLES

QC Sample	Analytical Group	Frequency [a]	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
MS / MSD or Sample duplicate	VOCs	5% of total samples planned for collection for each sampling technique utilized	Used to evaluate the precision of analytical measurements and potential interferences	RPDs ≤40%	A
Field Duplicates	VOCs	10% of total samples planned for collection for each sampling technique utilized.	Precision	Values > 5X LOQ: RPD must be ≤40% (soil) RPD must by ≤35% (aqueous) Values ≤ 5X LOQ: absolute difference ≤ 2x the LOQ	S & A
Split Samples	VOCs	10% of total samples planned for collection for each sampling technique utilized.	Precision/Accuracy	Values > 5X LOQ: RPD must be ≤40% (soil) RPD must by ≤35% (aqueous)	S & A
Cooler Temperature Indicator	VOCs	One per cooler requiring preservation	Accuracy/ Representative/Bias	Between 2 and 4 degrees Celsius (^{o}C)	S
Trip Blank	VOCs	One per cooler	Potential for cross-contamination during sample transport Accuracy/Bias	No analytes ≥ ½ LOQ, except common lab contaminants, which must be < LOQ.	S & A

[a] Refer to Worksheet #20 for a summary of QC samples by matrix and analytical group.

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12.1 Field and Laboratory QC Sample Terminology and Requirements

MPC for QC sampling results are used to evaluate project DQIs such as accuracy, precision, and comparability. The following sections provide discussion pertaining to planned field and laboratory QC sample types and DQIs including evaluation equations.

12.1.1 Trip Blanks

Trip blanks are samples that originate from American Society for Testing and Materials Type II, organic-free water prepared by the laboratory, shipped to the sampling site, and returned to the laboratory with samples to be analyzed for VOCs. One set of two 40-milliliter (mL) vials forms a trip blank and accompanies each cooler containing samples to be analyzed for VOCs by methods, such as EPA Methods SW8260B. Trip blanks are only analyzed for VOCs. Results of trip blank analyses are used to assess whether samples have been contaminated by VOCs during sample handling and transport to the laboratory.

Trip blanks should not contain any detections greater than half the limit of quantitation (LOQ). The analytical laboratory will analyze the source water for trip blanks routinely (once per week) as part of their internal QA/QC program. Certification results for the organic-free water will be evaluated against the project-specific action levels and quantitation limits to ensure the water contains no organic analytes above these criteria. Detections of VOCs in the trip blank and their possible impacts to the investigation are evaluated on a project-specific basis, typically during the data validation process.

12.1.2 Temperature Blank

A temperature blank is a container of water that is packed and shipped with the field samples requiring preservation by cooling to $4^{o}C \pm 2^{o}C$ to the laboratory. Upon arrival at the laboratory, the laboratory measures the temperature of the blank. This temperature reading is used to represent the conditions of the field samples during shipment to the laboratory. This information is used by both the laboratory and by the data validator. If temperature blank exceeds criteria of less than zero ^{o}C or greater than $6^{o}C$, the laboratory must notify the Project Manager or Project Chemist immediately for guidance.

12.1.3 Field Duplicates

A field duplicate is a generic term for two (or more) field samples taken at the same time in the same location. They are intended to represent the same population and are taken through all steps of the analytical preparation and analysis process in an identical manner and provide precision information for the data collection activity. There are two categories of field duplicate samples defined by the collection method: co-located field duplicates and subsample field duplicates. Co-located field duplicates are two or more independent samples collected from side-by-side locations at the same point in time and space so as to be considered identical. Co-locates are samples collected from adjacent locations or liners (e.g., laterally or vertically, in separate containers), or water samples collected from the same well at the same time that have not been homogenized. Subsample field duplicates samples are obtained from one sample collection at one sample location.

Field duplicates consist of either co-located or subsampled samples. Field duplicates for groundwater samples are generally considered to be co-locates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a co-located sample.

The interpretation of co-located duplicate data may be more complex than subsample duplicate data because of the number of variables associated with the results of this type of duplicate sample. Duplicate soil samples for VOC analysis shall always be co-located (i.e., not homogenized or otherwise processed or subsampled). Duplicates will be analyzed for the same analytical parameters as their associated parent sample. Collection of both co-located and subsampled versions of the same sample may be performed to aid in approximating sampling and analysis error. Field duplicates are generally collected at a frequency of 10 percent. Evaluation of field duplicate results is performed by calculation the Relative Percent Difference (RPD) between the parent sample and its field duplicate for every analyte of interest and matrix. The acceptance criteria for analyte-specific RPDs are developed during the DQO development process on a project-specific basis. The site-specific acceptance criteria for field duplicates can be found at the beginning of this worksheet in tabular form.

12.1.4 Splits

A field split sample, also called a replicate sample, is a single sample divided into two equal parts for analysis. The sample containers are assigned an identification (ID) number in the field such that they cannot be identified as replicate samples by the laboratory personnel performing the analysis. Specific locations are typically designated for collection of field replicates prior to the beginning of sample collection. Data from the split samples are used to assess sample handling variability. Split samples will be collected on a 10 percent bases. For the purpose of this investigation, the definitive data will be considered the true value for each analyte and location by virtue of the laboratories NELAC/ELAP accreditations when evaluating field screening data usability. The acceptance criteria found on the Field Quality Control Samples Measurement and Performance Criteria Table at the beginning of this worksheet will be used to determine to ability of the filed screening laboratory ability to meet overall project DQOs.

12.1.5 Analytical Method Blank

The analytical method blank is an analyte-free matrix which all reagents are added in the same volumes or proportions as used in sample processing and is carried through the complete sample preparation and analytical process. The purpose of this sample is to document contamination resulting from the analytical process. A method blank will be included in every analytical batch.

The detection of analytes in a method blank must not exceed the limit of detection (LOD). Corrective action shall be performed to eliminate the source of contamination prior to proceeding with analysis. After the source of contamination has been eliminated, all samples in the preparation batch shall be re-prepared and re-analyzed. Analytical data are not corrected for the presence of analytes in blanks. When an analyte is detected in the method blank and in the associated samples and corrective actions are not performed or are ineffective, the appropriate validation qualifier shall be applied to the sample results. The site-specific acceptance criteria for analytical method blanks can be in Worksheet #28.

12.1.6 Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD)

The LCSs are analyte-free water (for aqueous analyses) or reagents and glassware only (for soil analysis) spiked with all target analytes of interest for each analytical method. The LCS is analyzed to assess general method performance by the laboratory's ability to recover analytes from a control matrix. The spiking level must be greater than the lowest concentration standard used for calibration and less than or equal to the midpoint of the linear range calibrated. The LCS results are evaluated in conjunction with other related QC information to determine the acceptability of the data generated for the associated samples.

The LCS shall be carried through the complete sample preparation and analysis process. The LCS cannot be used as the continuing calibration verification. One LCS shall be included in every analytical batch. The performance of the LCS is evaluated against the QC acceptance limits provided in the DoD QSM, Version 5 (DoD, 2013). This evaluation can also include the use of control charts for establishing the internal lab limits and for identifying non-conformances.

Whenever an analyte in a LCS is outside the acceptance limit, corrective action shall be performed. After the system problems have been resolved and system control has been reestablished, all samples in the analytical batch shall be reanalyzed for only the out-of-control analyte(s). When an analyte in a LCS exceeds the upper or lower control limit and no corrective action is performed or the corrective action was ineffective, the appropriate validation qualifier will be applied to all affected results. The site-specific acceptance criteria for LCS/LCSD recoveries can be found in Worksheet #28.

12.1.7 Matrix Spikes/Matrix Spike Duplicates (MS/MSD)

The MS is used to access the performance of the method as applied to a particular matrix. MSs and MSDs are aliquots of samples spiked with known amounts of all target analytes. The spiking occurs in the laboratory, prior to sample preparation and analysis. The spiking level must be greater than the lowest concentration standard used for calibration and less than or equal to the midpoint of the linear range calibration.

A minimum of one MS sample and one MSD sample shall be collected per 20 samples per media collected. Sampling locations selected for the purpose of assigning a MS/MSD should be an area anticipated to be free from or have low concentrations of targeted analytes. During the acquisition of soil MS/MSD samples, field personnel will avoid areas that are stained or known to have high levels of targeted materials.

Only project-specific samples shall be used for spiking. The MS/MSD is designated on the Chain-of-Custody. The MS/MSD is used to document the bias of a method due to sample matrix. These sample results are not be used to control the analytical process. The acceptance criteria for the MS and MSD are evaluated against the QC acceptance limits developed during the DQO development process. If performance criteria are not being met by the MS and MSD samples, the analytical procedures and methods must be re-evaluated for appropriateness and correctness. For example, cleanup procedures may be needed to remove matrix interferences. The site-specific acceptance criteria for MS and MSD recoveries and RPD can be found at the beginning of this worksheet in tabular form by matrix.

12.1.8 Surrogate Spikes

Surrogates are organic compounds that are similar to the target analyte(s) in chemical structure and chemical behavior in the analytical process, but that are not normally found in environmental samples. The surrogate results are used to evaluate accuracy, method performance, and extraction efficiency. These surrogate compounds are spiked in environmental samples, control samples, and blank samples per the method requirements. The surrogate should be spiked at a concentration less than or equal to the midpoint of the linear range calibrated.

When the acceptance criteria of a surrogate recovery are not met, corrective action must be performed. Once the system problems have been resolved and system control has been reestablished, the sample is re-prepared and re-analyzed. If corrective actions are not performed or are ineffective, the appropriate validation qualifier shall be applied to the sample results. The site-specific acceptance criteria for surrogate recoveries can be found in Worksheet #28.

12.2 Data Quality Criteria

QC procedures are employed during chemical analysis to support and document the attainment of established method quality objectives. Whether these QC procedures support an assessment of general batch control or matrix-specific application, documentation includes calculating DQIs to verify data usability and contract compliance. DQIs were formerly referred to as the parameters of Precision, Accuracy, Representativeness, Comparability, and Completeness (PARCC). Acceptance criteria for PARCC are developed during the DQO development process. The basis for assessing each of these elements of data quality is discussed in the following subsections.

12.2.1 Precision

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as standard deviation, variance, percent difference, or range, in either absolute or relative terms. Precision data indicate how consistent and reproducible the field sampling or analytical procedures have been. Field duplicate precision is evaluated by calculating a RPD using the following equation:

$$RPD = |(D1-D2)/\{1/2(D1+D2)\}| \text{ X } 100$$

Where:

D1 = original sample concentration
D2 = duplicate sample concentration

If more than two field duplicate samples are collected from adjacent locations and analyzed, they are referred to as co-located field replicates. If two or more aliquots of the same sample are prepared and analyzed by the laboratory, these are referred to as laboratory replicates. Precision of replicate samples is evaluated by calculating the relative standard deviation (RSD) using the following equation:

$$\%RSD = \frac{\frac{\sum_{i=1}^{i=n} D_i - D^{\,2}}{n}}{D}$$

Where:

Di = the individual sample concentrations
D = the mean of n values
n = the total number of values

Possible causes of poor precision include sample heterogeneity, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability.

12.2.2 Accuracy

Accuracy is the degree of agreement of a measurement, or average of measurements, with an accepted reference or "true" value, and is a measure of bias in the system. Accuracy of measurement data will be assessed and controlled through the use of LCSs and LCSDs, surrogate spikes, site-specific matrix MSs and MSDs.

Results for LCS and surrogate spikes will be the primary indicators of accuracy. These results will be used to control accuracy within acceptable limits for definitive-level data. Field-designated MS/MSD samples will be employed for applicable methods to identify matrix-associated analytical influences or interferences that may affect the accuracy of the analytical data. As spiked samples are analyzed, spike recoveries will be calculated and compared to pre-established acceptance limits.

Accuracy/bias is

$$\text{MS \% recovery} = \frac{conc.\ of\ \ sample\ \ plus\ spike - conc.\ of\ \ unspiked\ \ sample}{value\ \ of\ \ spike\ \ added}\ x\ 100$$

$$\text{LCS target/surrogate \% recovery} = \frac{measured\ \ concentrat\ ion}{true\ (expected)\ \ concentrat\ ion}\ x\ 100$$

Trip blanks, field blanks, and equipment blanks monitor accuracy/bias by detecting any concentrations of analytes in water that was originally contaminant-free and comparing that to the field sample results.

12.2.3 Completeness

Completeness is a measure of the amount of adequate data obtained from the actual performance of measurement procedures compared to the amount expected to be obtained from error-free performance of the same measurement procedures under normal conditions. Completeness measures the extent to which the database resulting from a measurement effort fulfills objectives for the amount of data required. Completeness is defined as the valid data percentage of the total tests requested.

$$\textit{Completeness (\%)} = \frac{number\ \ of\ \ valid\ \ analyses\ \ per\ analyte\ \ in\ a\ matrix}{number\ \ of\ \ requested\ \ analyses\ \ per\ analyte\ \ for\ that\ \ matrix}\ x\ 100$$

Complete project data involves both satisfactory performance and documentation of field and laboratory procedures. Valid analyses are defined as those where the sample arrives at the laboratory intact, properly preserved, in sufficient quantity to perform the requested analyses, and accompanied by a completed chain-of-custody. Furthermore, the sample must be analyzed within the specified holding time and in such a manner that analytical QC acceptance criteria are met, with the following exception. Data qualified as estimated as a result of data validation are considered valid and counted towards completeness if still usable for the intended use of the data. Such data require evaluation to determine suitability for decision-making purposes. Rejected data are not valid data. Completeness for the entire project also involves completeness of field and laboratory documentation, whether all samples and analyses specified in the project-specific UFP-QAPP have been processed, and whether the procedures specified in the laboratory standard operating procedures have been followed.

The completeness goal for a project as a whole is 90 percent. The completeness goal is for the entire duration of the project (i.e., there is not a goal of 90 percent completeness per sampling round). The completeness goal for the analytical laboratory portion for each project is 95 percent. Failure to achieve the project completeness goal may necessitate re-sampling and re-analysis, or re-evaluation of DQOs.

Critical samples are samples that are used as the sole or primary source for making environmental decisions. These samples require a high level of data quality and completeness. Completeness is particularly relevant for soil samples, since recollecting some samples, particularly samples at depth, may be difficult or not feasible. However, all soil samples are not necessarily critical samples. Critical samples may be identified in the course of conducting environmental investigations. Critical samples will have a completeness goal of 100 percent for each analyte of concern in each matrix, and the completeness goal will be evaluated based on each sampling round.

12.2.4 Representativeness

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. The characteristics of representativeness are usually not quantifiable. Subjective factors to be considered in evaluating how representative a set of measurement data is of a property being measured include:

- Degree of homogeneity of the property or environmental matrices across a site;
- Consistency in applying field procedures;
- Degree of homogeneity of the property within a sample collected from one location at a site; and
- Available information on which a sampling plan is based.

Soil boreholes and well locations are chosen to represent the areas of interest at a site. To maximize representativeness of the data, sampling techniques, sample size, and sample locations are carefully chosen to yield samples representative of the particular location and time of sampling, and to produce samples that are collectively representative of the site as a whole. Properly installed monitoring wells verify that the groundwater being sampled originates from the aquifer of interest. Care must be taken to verify proper stabilization of measured water parameters, clarity, and color before groundwater samples are collected. Precautions, such as not operating combustion engines near a well during sampling, must be taken to prevent the introduction of extraneous analytes into environmental samples.

Soil samples are generally less homogeneous than water; therefore, it is important for the sampler and analyst to exercise good judgment when collecting soil samples or preparing soil samples for analysis. Samples exhibiting obvious lack of homogeneity, stratification, or lithologic changes should not be used as replicates. At the laboratory, measures shall be taken to collect aliquots for analysis that are representative of the whole sample. This includes premixing the sample and discarding large stones or debris from soil samples. For soil samples requiring volatiles analysis, premixing or homogenizing is generally not allowed, although removal of large stones or debris may be required. For analysis of volatile analytes in soil samples, representative subsamples will be prepared according to EPA Method SW5035A (or Method SW5030A until Method SW5035A is implemented).

12.2.5 Comparability

Comparability is the degree to which one data set can be compared to another data set measuring the same property. Comparability is assured through the use of established and approved sample collection techniques and analytical methods, consistency in the basis of analysis (dry weight, volume, etc.), consistency in reporting units, and analysis of standard reference materials.

Data comparability will be achieved by using standard units of measure, e.g., milligrams per liter for inorganics in water samples, µg/L for organics and metals in water and milligrams per kilogram (mg/kg) for both inorganics and organics in soil samples. Soil sample results will be reported on a dry weight basis, with percent solids or percent moisture reported for each sample.

The use of approved or standard methods to collect and analyze samples (in this case, American Standard for Testing and Materials [ASTM] and USEPA Methods), along with instruments calibrated against National Institute for Standards and Technology traceable standards will also help maintain comparability.

Comparability also depends on the other data quality characteristics. Only when data are judged to be representative of the environmental conditions, and when precision and accuracy are known, may data sets be compared with confidence.

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WORKSHEET #13: SECONDARY DATA CRITERIA AND LIMITATIONS TABLE

Secondary Data	Data Source	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
Historical Data	TCE Comprehensive Investigation at OMS – 28, Mobile, AL April 2007	Aerostar Environmental Services	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Analytical data may not reflect current site conditions.
Historical Data	Supplemental Comprehensive Investigation Groundwater Monitoring Report for ALARNG OMS – 28, Mobile, AL, April 2008	Aerostar Environmental Services	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Analytical data may not reflect current site conditions.
Historical Data	Supplemental Comprehensive Investigation Groundwater Monitoring Report for ALARNG OMS – 28, Mobile, AL, November 2008	Aerostar Environmental Services	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Leachability data may not be representative of other sites.
Historical Data	Supplemental Comprehensive Investigation Groundwater Monitoring Report for ALARNG OMS – 28, Mobile, AL, January 2011	Aerostar Environmental Services	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Analytical data may not reflect current site conditions.
Historical Data	Alabama Risk-Based Corrective Action Report, OMS – 28, Mobile, AL, March 2011	Thompson Engineering on behalf of Aerostar Environmental Services	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Analytical data may not reflect current site conditions.
Historical Data	Remedial Investigation Report for ALARNG, OMS – 28, Revision 1 Mobile, AL, December 2012	SAIC	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Analytical data may not reflect current site conditions.
Historical Data	Remedial Investigation Report for ALARNG, OMS – 28, Revision 2 Mobile, AL, May 2013	SAIC	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Analytical data may not reflect current site conditions.
Historical Data	Feasibility Study for the ALARNG OMS-28, Mobile, AL, February 2014	Leidos	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Analytical data may not reflect current site conditions.
Historical Data	Historical Research Study Report, OMS – 28, Mobile, AL, August 2015.	Louis Berger	Historical analytical data and investigation findings will be used to develop the CSM and the field sampling plan.	Aquifer characteristics at the aquifer testing area may not be representative of site groundwater.

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WORKSHEET #14: SUMMARY OF PROJECT TASKS

Worksheet #14 describes the project tasks to be conducted to acquire, manage, and evaluate the field investigation data in support of the Supplemental Data Gap Investigation. The project tasks include both tasks presented in USACE's Performance Work Statement (PWS) and additional tasks to address and complete the requirements of the field investigation, monitoring events, and reporting. The major project tasks include:

- Development of Work Plan/SSHP
- Field Investigation
- Risk Assessment
- Development of Reports

Project tasks shall be conducted in accordance with this WP and shall follow the guidance set forth in applicable SOPs (Appendix B) identified in Worksheet #21. Details of the field sampling and analysis tasks are presented in Worksheet #17. The following sections present the tasks to be performed in support of the field work.

14.1 DEVELOPMENT OF WORK PLAN / SSHP

This WP is developed following the UFP-QAPP guidance and addresses the USACE's PWS WP components: Project Management Plan, Quality Assurance Surveillance Plan, Sample and Analysis Plan, and Data Management Plan. The Site Safety and Health Plan (SSHP) is presented under separate cover.

14.2 SUPPLEMENTAL DATA GAP FIELD INVESTIGATION

A field investigation will be conducted consisting of the collection and analysis of soil and groundwater samples in support of the guidelines found in the ADEM document entitled "*Alabama Environmental Investigation and Remediation Guidance*" (ADEM, 2005) and USEPA guidance. For each analyte identified as a chemical of potential concern (COPC), the complete horizontal and vertical extent of groundwater impacts shall be delineated including any potential vadose zone soil source areas resulting from upgradient contamination. Interconnections between separate portions of impacted groundwater with common or distinct COPCs shall be defined and delineated, if present. Previous data from the sampling of groundwater wells indicated that the deeper aquifer underlying the clay confining unit did not detect chemicals exceeding USEPA Maximum Contaminant Level (MCLs). However, groundwater samples from these deeper wells will be collected to confirm the previous findings. The following are the field activities that will performed as part of the Supplemental Data Gap Investigation. Each activity is discussed in detail in Worksheet #17.

14.2.1 Brush Clearing

Heavy brush and small trees will need to be removed from the investigation area in order to access the monitoring wells for sampling and for the direct push technology (DPT) rig (to be used to collect soil and groundwater samples and advanced the LLMIP/HPT) and support vehicles to assess the area of field screening and sampling. Details of the brush clearing activity are provided in Section 17.1.1 in Worksheet #17.

14.2.2 Monitoring Well Inventory

Monitoring wells will be identified and inspected during the first sampling event. Each well shall be identified based on well tags or markings. Observations on the general condition of the surface completion and casing will be recorded on a Well Maintenance form. Photographs of each well will be taken and included with the Well Maintenance form. Details of the well inventory activity are provided in Section 17.1.3 in Worksheet #17.

14.2.3 Monitoring Well Sampling

Two groundwater sampling events are planned for the existing monitoring well network. The results of the first event will give a current understanding of the condition of the groundwater plume and help plan the soil and groundwater screening and sampling effort. The analytical suite for both sampling events includes TCL VOCs by Method 8260B of the 12 existing monitoring wells. A complete round of water levels will be collected prior to sampling activities. Details of the monitoring well groundwater sampling activity are provided in Section 17.1.3 in Worksheet #17.

14.2.4 Supplemental Data Gap Investigation

For the supplemental data gap investigation, field screening and sampling of soil will be performed to determine new/refine the existing soil source area utilizing multi-interface probe and onsite laboratory analysis. In addition, the collection of groundwater grab samples will be performed to refine horizontal and vertical delineation of the plume in anticipation of future installation of permanent monitoring wells and remediation alternatives evaluation. Details of the Supplemental Data Gap Investigation activity are provided in Section 17.2 in Worksheet #17. A brief description of each activity is provided below.

Utility Location

AL811 and AECOM's subcontract utility location service will clear boring locations of utilities. Borehole locations may be field adjusted by the Geologist as needed.

Soil Source Area Characterization

Soil source characterization will begin with a track mounted drill rig using DPT. The DPT will utilize a LLMIP / Electrical Conductance (EC) to characterize subsurface conditions and identify concentrations of contaminants in soil that may be contributing to groundwater contamination. Soil source sampling will be collected with the DPT. Boring locations for soil samples will be based on MIP/EC results from depths suspected to be a source. Continuous soil cores will be collected and screened at 2-foot intervals with an organic vapor analyzer such as a photoionization detector (PID). From each soil boring, samples will be collected from a maximum of three depths: surface soil; areas of highest VOC concentration as identified with the MIP or PID; and a foot above the soil/water interface. Soil samples will be sent to the on-site mobile laboratory for analysis of TCE and PCE. Splits soil samples will be collected (10%) and sent to an off-site fixed laboratory for QC to be analyzed for TCL VOCs by Method 8260. Field duplicate samples (10%), MS/MSD (5%), and equipment blanks (5%), if necessary, will be collected and sent to the mobile laboratory for analysis.

Groundwater Plume Delineation

The DPT will also be utilized to advance a HPT to delineate the subsurface geology. The HPT tool will be used for hydrostratigraphic screening to determine hydraulic conductivity of the aquifer for development of treatment alternatives. Both the LLMIP and HPT will be advanced to a depth of 35-feet bgs or top of the clay confining unit. Samples below the clay confining unit are not anticipated because historical groundwater samples from the deeper aquifer underlying the clay confining unit have been non-detect for VOCs. Groundwater grab samples will be collected using the DPT in order to characterize the horizontal and lateral extent of groundwater contamination. Locations and depths will be based on LLMIP/EC, soil sample, and groundwater sample (from well sampling) results. Groundwater samples will be collected through a screen point sampler using a peristaltic pump. The groundwater grab samples will be analyzed by the on-site mobile laboratory for TCE and PCE using Method 8260. Split samples will be collected (10%) and sent to an off-site fixed laboratory for QC for analysis of TCL VOCs by Method 8260 to verify the results from the on-site mobile laboratory. Field duplicate samples (10%), MS/MSD (5%), and equipment blanks (5%), if necessary, will be collected and sent to the mobile lab for analysis

14.2.5 Survey

All LLMIP/HPT and DPT sample locations will be surveyed using a global positioning system (GPS) for X and Y coordinates. Details of the survey activity are provided in Section 17.2.4 in Worksheet #17.

14.2.6 Sample Management

Field investigation samples will be appropriately managed from the time of collection through the time of relinquishment to ensure sample quality and representativeness. Each sample will be assigned a unique sample ID for tracking purposes. Sample labels will be affixed to each sample container to identify the sample, the date and time of collection, site name, the lab analyses, preservative if any, sample type, and the field personnel who collected the sample. Samples will be placed on ice immediately after collection. Chain of custody forms and samples will be packed in coolers with ice. Custody seals will be affixed to the lid interface of each cooler to ensure that the samples have not been tampered with. Coolers will be shipped to the analytical laboratory. Sample identification numbers are named as described in Worksheet #27.

14.2.7 Equipment Decontamination

Equipment decontamination activities will be conducted on field equipment that comes in contact with site media to prevent cross-contamination and to have better confidence in sampling data. Two types of equipment decontamination procedures will be implemented: one for reusable sampling equipment that comes into contact with contaminated site media; and a second procedure for non-sampling equipment. Reusable sampling equipment will be decontaminated using the 2-step decontamination process. Reusable equipment may include spoons, trowels, and/or split spoon samplers, and down-hole pumps. Two buckets will be placed in secondary containment and in the following series: 1) detergent bath with alconox/liquinox, and 2) water bath. Reusable sampling equipment will be cleaned by washing the equipment surface beginning at Step 1 and proceeding to Step 2. Decontamination water will be changed out as needed.

Pressure washing/steam washing activities will be conducted for non-sampling equipment using a portable pressure/steam washer. Non-sampling equipment of direct-push rods will be placed within secondary containment and pressure/steam washed to remove residual soil and chemicals from the equipment surface.

All decontamination fluids will be collected and appropriately managed in accordance with state and federal laws. Details of the decontamination activity are provided in Section 17.4 in Worksheet #17.

14.2.8 IDW Management

Investigative derived waste (IDW) management and sampling activities will be conducted to properly stage IDW, appropriately manage IDW, and characterize IDW for disposal. Sources of IDW will include soil cuttings, well purge water, and decontamination fluids. During field investigation, activities, waste minimization practices will be implemented to the extent practical. Wastes such as consumable materials, supplies, and equipment will be cleaned, as necessary, and disposed of as municipal trash. Details of the IDW management activity are provided in Section 17.5 in Worksheet #17.

14.2.9 Laboratory Analysis, Data Evaluation, Reporting, Validation, and Management

Samples will be analyzed to quantify chemical concentrations in soil and groundwater. The laboratory analyses by matrix are presented below:

- Soil
    - PCE and TCE by USEPA Method 8260B to the mobile on-site laboratory
    - 10% split samples for TCL VOC by USEPA Method 8260B to the fixed off-site laboratory
- Groundwater
    - Monitoring Wells: TCL VOC by USEPA Method 8260B to the fixed off-site laboratory
    - Grab DPT samples: PCE and TCE by USEPA Method 8260B to the mobile on-site laboratory
    - Grab DPT samples: 10% split samples for TCL VOC by USEPA Method 8260B to the fixed off-site laboratory

On-Site analyses by the mobile laboratory will be performed by Columbia Technologies located in Columbia, MD and off-site analyses by the fixed laboratory will be performed by Gulf Coast Analytical Laboratories, Inc. (GCAL) in Baton Rouge, LA in accordance with laboratory SOPs (Worksheet #23). Data evaluation, reporting, validation, and management tasks will be conducted as described below.

Data Evaluation

Analytical data and investigation findings will be evaluated to determine if PQOs have been satisfied and to identify if additional sample collection and further evaluation is warranted. If PQOs have not been met, additional sample collection and analysis may be warranted.

Data Reporting

The analytical laboratory will verify, reduce, and report data as specified in their laboratory quality assurance plan and in accordance with their subcontract. Reported data will be provided as electronic data deliverables (EDDs). The laboratory EDD format will be consistent with Appendix E of the DoD Quality Systems Manual for Environmental Laboratories Version 5.0 (DoD, 2013).

Analytical data will be submitted by the laboratory as an electronic file. The database will be passed through internal verification and validation checks. Internal verification and validation checks are performed to identify data entries that exceed the specified QC criteria. If QC criteria are not met or if errors are identified due to an incorrect or incomplete laboratory submittal, the data package will be returned to the laboratory for correction and re-submittal.

The analytical data will be reviewed before it is validated to address time-critical issues such as re-extraction, matrix interference, and holding times. The data usage and the appropriate QA/QC level will be evaluated.

Data Validation

Project analytical data will be validated to assess PARCC of the data package in accordance with the data validation procedures identified in Worksheet #36.

The analytical data will be validated to ensure that the laboratory has met analytical SOP requirements (Worksheet #23) and the requirements documented in the DoD Quality Systems Manual for Environmental Laboratories Version 5.0 (DoD, 2013). In addition, data validation quality checks (i.e., evaluating the precision and accuracy) will be performed by comparing the reported concentrations of each analyte to the corresponding limits of quantitation (LOQs).

Data Management

Data management tasks include analytical database management and archiving project documents and records.

Analytical Database

A database will be developed to effectively manage analytical data. Validated data and project screening criteria (PSC) will be imported into the database. The database will be used to perform data queries and to screen analytical data against the applicable screening criteria.

Analytical Data Archiving

Project documents and records will be archived in an electronic database maintained by the AECOM Greenville, South Carolina office. Project documents and records include sample collection documents and records, analytical records, project data assessment records, and off-site analysis documents and records. Project documents and records will be retained for a 10-year period and stored in accordance with the DoD QSM Version 5.0 (DoD, 2013). All validated analytical data will be uploaded to the U.S. Army Environmental Restoration Information System (ERIS).

The analytical laboratory will retain analytical data records for at least 5 years in accordance with the DoD QSM Version 5.0 (DoD, 2013).

14.3 RISK ASSESSMENT

A human health risk assessment and screening level ecological risk assessment will be conducted at this site. Potential risks to human receptors at each site will be evaluated using a four-step risk-based screening level approach. The four-step process includes: 1) selecting COPCs, 2) identifying exposure point concentrations, 3) developing site-specific screening levels, and 4) a comparison of exposure point concentrations to site-specific screening levels. In addition, a vapor intrusion evaluation will be performed. The risk assessments shall incorporate existing data as well as the new data to be collected as part of this investigation. The screening level ecological risk assessment will incorporate Steps 1 and 2 of the EPA Ecological Risk Assessment Guidance for Superfund process. A stand-alone BRA Report will be submitted.

Three exposure domains will be utilized to assess the site – on-site, the residential area north of the site, and the wooded area west of the site (MAA property). Human health scenarios will include industrial, trespasser, construction worker, and resident. The screening level ERA will evaluate terrestrial receptors only.

14.3.1 Selection of Chemicals of Potential Concern

The soil and groundwater analytical data will be screened against conservative risk-based screening levels (e.g., USEPA Regional Screening Levels [RSLs] for residential exposure) in order to identify COPCs. The maximum detected concentrations of each analyte will be compared to the applicable screening level. COPCs are described as chemicals that have the potential to pose unacceptable risk to human receptors.

14.3.2 Identification of Exposure Point Concentrations

Exposure points for the receptors will be identified based on the understanding of exposure pathways developed through preparation of the refined CSM. Concentrations of the COPCs in soil and groundwater at these exposure points will be derived based on analytical results from the investigation.

14.3.3 Development of Site-Specific Screening Levels

Site-specific screening levels will be developed for the COPCs identified for each site. The current and potential future exposure scenarios identified for each site are described in Section 10.4. Accordingly, site-specific screening levels will be developed based on an industrial exposure scenario for the COPCs identified in soil and groundwater. Site-specific screening levels will also be developed for the COPCs in soil and groundwater on a potential residential exposure scenario.

The site-specific screening levels will be derived using standard risk equations as provided in the USEPA on-line Regional Screening Level calculator, available at http://epa-prgs.ornl.gov/cgibin/chemicals/csl_search. These equations are based on the intake and risk equations presented in Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A) (USEPA, 1989) and subsequent USEPA guidance. The most current toxicity values will be obtained from the hierarchy of USEPA-approved sources as provided in Human Health Toxicity Values in Superfund Risk Assessments Memorandum (USEPA, 2003). A target risk level of 1×10^{-6} for carcinogens and a target hazard index of 1.0 for non-carcinogenic effects will be used for development of the screening levels, as specified in the ARBCA (ADEM, 2008). The lower of the carcinogen and non-carcinogen screening levels will be used for each COPC.

14.3.4 Comparison of Site-Specific Screening Levels

Exposure point concentrations for each COPC will be compared to the corresponding risk-based site-specific screening level. COPCs with exposure point concentrations greater than the site-specific screening level will be retained as COCs.

14.3.5 Vapor Intrusion Evaluation

An evaluation of the potential for a complete vapor intrusion pathway into overlying or nearby existing structures (including the residential properties located to the north of the site) in accordance with the requirements and references provided in the Defense Environmental Restoration Program Management Manual (DoDM 4715.20, March 9, 2012), Section 6.c. The evaluation of the potential risk from vapor intrusion will follow the recent EPA guidance on VI (OSWER Technical Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air – USEPA. 2015b), which calls for a phased approach to assessing VI risk. The first phase will be a screening of site data using the EPA Vapor Intrusion Screening Level calculator. Soil and groundwater samples from the most northerly sample locations will be utilized to assess the potential for risk to off-site residents, due to the entry restrictions on these private residential properties. Should the VISL screenings indicate a potential risk, then recommendations for additional assessment and/or remedial activities will be made. Collection of sub-slab or indoor air samples is not planned as part of this field effort.

14.4 DEVELOPMENT OF REPORTS

14.4.1 Supplemental Data Gap Investigation Report and 2015 Groundwater Monitoring Report

A Supplemental Data Gap Investigation Report and Groundwater Monitoring report will be prepared and it will present the data collected as part of the field investigation and first round of groundwater samples from existing wells. The report will include potentiometric maps of the surficial aquifer (a potentiometric map of the deeper aquifer is not possible because only three wells exist in this zone). Evaluation of the current monitoring well network will be made and may include recommendations for additional wells or abandonment of wells.

In addition, a CSM will be developed with the new data derived from this investigation and a 3-D visualization of the CSM will be presented. The CSM will be developed in accordance with Standard Guide for Developing Conceptual Site Models for Contaminated Sites (ASTM, 2014), Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA 1988), and

Data Quality Objectives Process for Hazardous Waste Site Investigations: Final Guidance (USEPA 2000). The illustrative 3-D CSM shall incorporate site topography, lithology, hydrostratigraphy and contaminant concentrations.

A groundwater model will be included with the report. A 3-D numerical flow and transport model for Monitored Natural Attenuation and risk assessment evaluation will be developed. The model will include construction and calibration of 3-D numerical flow model, input and calibration of chemical data to flow model, internal review of model parameters and calibration, and preparation and of a modeling report to be included in the appendices.

14.4.2 Feasibility Study Evaluation Letter Report

A letter report will be prepared and will assess the effectiveness and time constraints of the alternatives evaluated in the 2014 Final FS and make recommendations as to the viability of the alternatives based on the newly collected soil and groundwater data collected as part of this investigation.

14.4.3 Second Groundwater Monitoring Report

A groundwater monitoring report will be prepared to document the second groundwater monitoring event. Plume orientation and COC concentration trends will be evaluated.

WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLES

Analytical data collected during the investigation will be evaluated using relevant environmental screening criteria including:

- Soil
    - USEPA RSLs (residential, industrial, soil screening level [SSL]) (USEPA, 2015)
    - ADEM Preliminary Screening Levels (PSVs) (residential and industrial) (ADEM, 2008, Table 2-2)
- Groundwater
    - USEPA MCLs (USEPA, 2015a)
    - USEPA Region 4 Tap Water RSLs (USEPA, 2015a)
    - ADEM PSVs (ADEM, 2008; Table 2-2),
- Investigation Derived Waste
    - 40 Code of Federal Regulations (CFR) Section 261 (CFR, 2015)

Analytical data generated during the investigation will be screened against PSC identified in Worksheet #15.1 through Worksheet #15.4.

15.1 Screening Criteria and Reference Limits

PSCs for each media (soil and groundwater) for each laboratory (mobile and fixed) for each chemical are provided in Worksheets 15-1 (soil by the fixed off-site laboratory), 15-2 (soil by the mobile on-site laboratory), 15-3 (groundwater by the fixed off-site laboratory), and 15-4 (groundwater by the mobile on-site laboratory). The lowest analyte concentration for each screening criteria is identified in the worksheets as the PSC. Chemical concentrations that exceed the PSC will be identified as a COPC. The laboratory specific values for the LOQ, limit of detection (LOD), and method detection limit (MDL) are also provided on Worksheets 15-1 through 15-4. Based on limitations of the analytical instrumentation, the standard method reporting limit may exceed the screening criteria. In addition, the effects of sample dilution and moisture content may result in a higher reported concentration. In such cases, analytes not detected in samples would be reported at a concentration that exceeds the screening criteria. Any instance where non-detected data exceeds the screening criteria will be noted in the data tables and discussed in the associated Data Assessment Reports.

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Worksheet 15.1: Project Action Limits and Laboratory Specific Limits for Soil Fixed Off-Site Laboratory (GCAL)

Analyte	CAS No.	Screening Criteria					Project Screening Criteria	Laboratory Specific Limits[a]		
		EPA Residential RSL	EPA Industrial RSL	EPA SSL	ADEM Residential PSV	ADEM Industrial PSV		LOQs	LODs	MDLs
Volatile Organic Compounds by 8260B (mg/kg)										
1,1-Dichloroethane	75-34-3	3.6	16	0.00078^{R}	51	170	0.00078^{R}	0.005	0.0005	0.00025
1,1-Dichloroethene	75-35-4	23	100	0.0025^{M}	12	41	0.0025^{M}	0.005	0.0005	0.00025
1,1,1-Trichloroethane	71-55-6	810	3,600	0.07^{M}	1,200	1,200	0.07^{M}	0.005	0.0005	0.00025
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	4,000	17,000	14^{R}	-	-	14^{R}	0.005	0.001	0.0005
1,1,2-Trichloroethane	79-00-5	0.15	0.63	1.3 X 10^{-5R}	0.73	1.6	1.3 X 10^{-5R}	0.005	0.0005	0.00025
1,1,2,2-Tetrachloroethane	79-34-5	0.6	2.7	3.0 X 10^{-5R}	0.41	0.93	3.0 X 10^{-5R}	0.005	0.0005	0.00025
1,2-Dibromo-3-chloropropane	96-12-8	0.0053	0.064	1.4 X 10^{-7R}	0.46	2	1.4 X 10^{-7R}	0.005	0.002	0.0005
1,2-Dichlorobenzene	95-50-1	180	930	0.03^{R}	600	600	0.03^{R}	0.005	0.0005	0.00025
1,2-Dibromoethane	106-93-4	0.036	0.16	2.1 X 10^{-6R}	-	-	2.1 X 10^{-6R}	0.005	0.002	0.0005
1,2-Dichloroethane	107-06-2	0.46	2.0	4.8 X 10^{-5R}	0.28	0.6	4.8 X 10^{-5R}	0.005	0.0005	0.00025
1,2-Dichloropropane	78-87-5	1.0	4.4	0.00015^{R}	34	74	0.00015^{R}	0.005	0.0005	0.00025
1,2,3-Trichlorobenzene	87-61-6	6.3	93	0.0021^{R}	-	-	0.0021^{R}	0.005	0.0005	0.0005
1,2,4-Trichlorobenzene	120-82-1	5.8	26	0.0012^{R}	6.2	22	0.0012^{R}	0.005	0.0005	0.0005
1,3-Dichlorobenzene	541-73-1	-	-	-	53	600	53	0.005	0.0005	0.00025
1,4-Dichlorobenzene	106-46-7	2.6	11	0.00046^{R}	3.4	7.9	0.00046^{R}	0.005	0.0005	0.00025
2-Butanone	78-93-3	2,700	19,000	0.12^{R}	2,200	11,000	0.12^{R}	0.005	0.002	0.0005
2-Hexanone	591-78-6	20	130	0.00088^{R}	-	-	0.00088^{R}	0.005	0.002	0.0005
4-Methyl-2-pentanone	108-10-1	530	5,600	0.028^{R}	530	4,700	0.028^{R}	0.005	0.0005	0.00025
Acetone	67-64-1	6,100	67,000	0.29^{R}	1,400	5,400	0.29^{R}	0.025	0.002	0.0005
Benzene	71-43-2	1.2	5.1	0.00023^{R}	0.64	1.4	0.00023^{R}	0.005	0.0005	0.00025
Bromochloromethane	74-97-5	15	63	0.0021^{R}	-	-	0.0021^{R}	0.005	0.001	0.0005
Bromodichloromethane	75-27-4	0.29	1.3	3.6 X 10^{-5R}	0.82	1.8	3.6 X 10^{-5R}	0.005	0.0005	0.00025

		Screening Criteria						**Laboratory Specific Limits**[a]		
Analyte	**CAS No.**	**EPA Residential RSL**	**EPA Industrial RSL**	**EPA SSL**	**ADEM Residential PSV**	**ADEM Industrial PSV**	**Project Screening Criteria**	**LOQs**	**LODs**	**MDLs**
Volatile Organic Compounds by 8260B (mg/kg)										
Bromoform	75-25-2	19	86	0.00087^{R}	62	220	0.00087^{R}	0.005	0.001	0.0005
Bromomethane	74-83-9	0.68	3.0	0.00019^{R}	0.39	1.3	0.00019^{R}	0.005	0.002	0.0005
Carbon Disulfide	75-15-0	77	350	0.024^{R}	36	720	0.024^{R}	0.005	0.0005	0.00025
Carbon Tetrachloride	56-23-5	0.65	2.9	0.00018^{R}	0.25	0.55	0.00018^{R}	0.005	0.0005	0.00025
cis-1,2-Dichloroethene	156-59-2	16	230	0.0011^{R}	4.3	15	0.0011^{R}	0.005	0.0005	0.00025
cis-1,3-Dichloropropene	10061-01-5	-	-	-	0.78	1.8	0.78	0.005	0.0005	0.00025
Chlorobenzene	108-90-7	28	130	0.0053^{R}	15	53	0.0053^{R}	0.005	0.0005	0.00025
Chloroethane	75-00-3	1,400	5,700	0.59^{R}	3	6.5	0.59^{R}	0.005	0.0005	0.00025
Chloroform	67-66-3	0.32	1.4	6.1×10^{-5R}	0.22	0.47	6.1×10^{-5R}	0.005	0.0005	0.00025
Chloromethane	74-87-3	11	46	0.0049^{R}	47	160	0.0049^{R}	0.005	0.002	0.0005
Cyclohexane	110-82-7	650	2,700	1.3^{R}	-	-	1.3^{R}	0.005	0.0005	0.00025
Dibromochloromethane	124-48-1	0.75	3.3	4.5×10^{-5R}	1.1	2.6	4.5×10^{-5R}	0.005	0.0005	0.00025
Dichlorodifluoromethane	75-71-8	8.7	37	0.03^{R}	9.4	31	0.03^{R}	0.005	0.0005	0.00025
Ethylbenzene	100-41-4	5.8	25	0.0017^{R}	400	400	0.0017^{R}	0.005	0.0005	0.00025
Isopropylbenzene	98-82-8	190	990	0.074^{R}	57	200	0.074^{R}	0.005	0.0005	0.00025
Methyl acetate	79-20-9	7,800	1.25×10^{5R}	0.41^{R}	-	-	0.41^{R}	0.005	0.001	0.0005
Methylcyclohexane	108-87-2	-	-	-	-	-	NS	0.005	0.0005	0.00025
Methylene Chloride	75-09-2	35	320	0.0013^{M}	9.1	21	0.0013^{M}	0.01	0.002	.001
Methyl tert-butyl ether (MTBE)	1634-04-4	47	210	0.0032^{R}	-	-	0.0032^{R}	0.005	0.0005	0.00025
Styrene	100-42-5	600	3,500	0.11^{M}	1,700	1,700	0.11^{M}	0.005	0.0005	0.00025
Tetrachloroethene	127-18-4	8.1	39	0.0018^{R}	0.48	1.3	0.0018^{R}	0.005	0.001	0.0005
Toluene	108-88-3	490	4,700	0.076^{R}	520	520	0.076^{R}	0.005	0.0005	0.00025
Trichloroethene	79-01-6	0.41	1.9	0.0001^{R}	0.053	0.11	0.0001^{R}	0.005	0.0005	0.00025

Analyte	CAS No.	Screening Criteria					Project Screening Criteria	Laboratory Specific Limits[a]		
		EPA Residential RSL	EPA Industrial RSL	EPA SSL	ADEM Residential PSV	ADEM Industrial PSV		LOQs	LODs	MDLs
Volatile Organic Compounds by 8260B (mg/kg)										
Trichlorofluoromethane	75-69-4	73	310	0.073[R]	39	200	0.073[R]	0.005	0.0005	0.00025
trans-1,2-Dichloroethene	156-60-5	160	2,300	0.011[R]	6.9	23	0.011[R]	0.005	0.0005	0.00025
trans-1,3-Dichloropropene	10061-02-6	-	-	-	0.78	1.8	0.78	0.005	0.0005	0.00025
Vinyl Chloride	75-01-4	0.059	1.7	6.5×10^{-6}[R]	0.079	0.75	6.5×10^{-6}[R]	0.005	0.0005	0.00025
Xylene, Total	1330-20-7	65	280	0.019[R]	27	420	0.019[R]	0.015	0.0015	0.005

Notes:
mg/kg - milligrams per kilogram

[a] Laboratory-specific LOQs, LODs, and MDLs are limits that the laboratory can achieve when performing a specific analytical method.

[R] – Risk-Based SSL

[M] – MCL-Based SSL

RSL - Regional Screening Level, USEPA, June 2015 (based on HQ=0.1).

ADEM - Alabama Department of Environmental Management

PSV - Preliminary Screening Levels as provided in ADEM Alabama Risk-Based Corrective Action Guidance Manual, Table 2-2, April 2008

SSL – Soil Screening Level, USEPA, June 2015. Either risk-based [R] or MCL-based [M], lower value used (based on HQ=0.1 and Dilution Attenuation Factor [DAF]=1).

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Worksheet 15.2: Project Action Limits and Laboratory Specific Limits for Surface and Subsurface Soil Mobile On-Site Laboratory (Columbia Technology)

Analyte	CAS No.	Screening Criteria					Project Screening Criteria	Laboratory Specific Limits[a]		
		EPA Residential RSL	EPA Industrial RSL	EPA SSL	ADEM Residential PSV	ADEM Industrial PSV		LOQs	LODs	MDLs
Volatile Organic Compounds by 8260B (mg/kg)										
Tetrachloroethene	127-18-4	8.1	39	0.0018[R]	0.48	1.3	0.0018[R]	0.0144	0.007	0.0031
Trichloroethene	79-01-6	0.41	1.9	0.0001[R]	0.053	0.11	0.0001[R]	0.0159	0.007	0.0029

Notes:

mg/kg - milligrams per kilogram

[a] Laboratory-specific LOQs, LODs, and MDLs are limits that the laboratory can achieve when performing a specific analytical

[R] – Risk-Based SSL

[M] – MCL-Based SSL

RSL - Regional Screening Level, USEPA, June 2015 (based on HQ=0.1).

ADEM - Alabama Department of Environmental Management

PSV - Preliminary Screening Levels as provided in ADEM Alabama Risk-Based Corrective Action Guidance Manual, Table 2-2, April 2008

SSL – Soil Screening Level, USEPA, June 2015. Either risk-based [R] or MCL-based [M], lower value used (based on HQ=0.1 and Dilution Attenuation Factor [DAF]=1).

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Worksheet 15.3: Project Action Limits and Laboratory Specific Limits for Groundwater Fixed Off-Site Laboratory (GCAL)

Analyte	**CAS Number**	**Screening Criteria**			**Project Screening Criteria**	**Laboratory Specific Limits**		
		USEPA MCL	**USEPA RSL Tap Water**	**ADEM PSV**		**LOQ**	**LOD**	**MDL**
Analytical Group: TCL Volatile Organic Compounds by EPA Method SW8260B in µg/L								
1,1-Dichloroethane	75-34-3	--	2.7	2.7	2.7	1.0	0.50	0.20
1,1-Dichloroethene	75-35-4	7	28	7	7	1.0	0.50	0.20
1,1,1-Trichloroethane	71-55-6	200	800	200	200	1.0	0.50	0.20
1,1,2-Trichloroethane	79-00-5	5	0.041	5	0.041	1.0	0.50	0.20
1,1,2,2-Tetrachloroethane	79-34-5	--	0.076	0.076	0.076	1.0	0.50	0.20
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	--	5,500	5,500	5,500	1.0	0.50	0.20
1,2,3-Trichlorobenzene	87-61-6	--	0.7	0.7	0.7	1.0	0.50	0.20
1,2,4 Trichlorobenzene	120-82-1	70	0.4	70	0.4	1.0	0.50	0.20
1,2-Dichlorobenzene	95-50-1	600	30	600	30	1.0	0.50	0.20
1,2-Dichloroethane	107-06-2	5	0.17	5	0.17	1.0	0.50	0.20
1,2-Dichloropropane	78-87-5	5	0.44	5	0.44	1.0	0.50	0.20
1,2-Dibromoethane (EDB)	106-93-4	0.05	0.0075	0.05	0.0075	1.0	0.50	0.20
1,3-Dichlorobenzene	541-73-1	--	--	--	NS	1.0	0.50	0.20
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.2	0.000334	0.2	0.000334	1.0	0.50	0.20
1,4-Dichlorobenzene	106-46-7	75	0.48	75	0.48	1.0	0.50	0.20
2-Butanone (MEK)	78-93-3	--	560	560	560	5.0	0.50	0.20
2-Hexanone	591-78-6	--	3.8	3.8	3.8	5.0	1.0	0.5
4-Methyl-2-pentanone (MIBK)	108-10-1	--	120	120	120	5.0	0.5	0.20
Acetone	67-64-1	--	1,400	1,400	1,400	5.0	1.0	0.50
Benzene	71-43-2	5	0.45	5	0.45	1.0	0.50	0.20
Bromochloromethane	74-97-5	--	8.3	8.3	8.3	1.0	0.50	0.20
Bromodichloromethane	75-27-4	80	0.13	80	0.13	1.0	0.50	0.20
Bromoform	75-25-2	80	3.3	80	3.3	1.0	0.50	0.25
Bromomethane	74-83-9	--	0.75	0.75	0.75	1.0	1.0	0.50
Carbon disulfide	75-15-0	--	81	81	81	1.0	0.50	0.20
Carbon tetrachloride	56-23-5	5	0.45	5	0.45	1.0	0.50	0.25
Chlorobenzene	108-90-7	100	7.8	100	100	1.0	0.50	0.20
Chloroethane	75-00-3	--	2,100	2,100	2,100	1.0	0.50	0.25
Chloroform	67-66-3	80	0.22	80	0.22	1.0	0.50	0.20
Chloromethane	74-87-3	--	19	19	19	1.0	0.50	0.20
cis-1,2-Dichloroethene	156-59-2	70	3.6	70	3.6	1.0	0.50	0.20
cis-1,3-Dichloropropene	10061-01-5	--	--	--	NS	1.0	0.50	0.20

Analyte	**CAS Number**	**Screening Criteria**			**Project Screening Criteria**	**Laboratory Specific Limits**		
		USEPA MCL	**USEPA RSL Tap Water**	**ADEM PSV**		**LOQ**	**LOD**	**MDL**
Analytical Group: TCL Volatile Organic Compounds by EPA Method SW8260B in µg/L								
Cyclohexane	110-82-7	--	1,300	1,300	1,300	2.0	1.0	0.50
Dibromochloromethane	124-48-1	80	0.17	80	0.17	1.0	0.50	0.20
Dichlorodifluoromethane (Freon 12)	75-71-8	--	20	20	20	1.0	0.50	0.20
Ethylbenzene	100-41-4	700	1.5	700	1.5	1.0	0.50	0.20
Isopropylbenzene	98-82-8	--	45	45	45	1.0	0.50	0.20
Methyl Acetate	79-20-9	--	2,000	2,000	2,000	5.0	2.0	1.0
Methylcyclohexane	108-87-2	--	--	--	NS	1.0	0.50	0.20
Methyl tert-butyl ether (MTBE)	1634-04-4	--	14	14	14	1.0	0.50	0.20
Methylene chloride	75-09-2	5	11.4	5	5	5.0	0.50	0.20
Styrene	100-42-5	100	120	100	100	1.0	0.50	0.20
Tetrachloroethene	127-18-4	5	4.1	5	4.1	1.0	0.50	0.20
Toluene	108-88-3	1,000	110	1,000	110	1.0	0.50	0.20
trans-1,2-Dichloroethene	156-60-5	100	36	100	36	1.0	0.50	0.20
trans-1,3-Dichloropropene	10061-02-6	--	--	--	NS	1.0	0.50	0.20
Trichloroethene	79-01-6	5	0.28	5	0.28	1.0	0.50	0.20
Trichlorofluoromethane (Freon 11)	75-69-4	--	110	110	110	1.0	0.50	0.20
Vinyl chloride	75-01-4	2	0.019	2	0.019	1.0	0.50	0.20
Xylenes (total)	1330-20-7	10,000	19	10,000	19	3.0	1.0	0.40

Notes:
MCLs - Maximum Contaminant Level (USEPA, April 2012).
RSL - Regional Screening Level
TCL - Target Compound List
NS - No Standard
RSL - Regional Screening Level for tap water, based on risk of 10-6 for carcinogens and HQ of 0.1 for noncarcinogens (June 2015).
MCLs shown for chloride, manganese, and sulfate are Secondary Drinking Water Regulations.
MCLs for bromodichloromethane, bromoform, chloroform, and dibromochloromethane are based on the 1998 Final Rule for Disinfectants and Disinfection By-Products: The total for trihalomethanes is 80 µg/L.
ADEM PSV - Alabama Department of Environmental Management Preliminary Screening Value is the MCL, if available; otherwise, it is the RSL (June 2015)(based on guidance outlined in the Alabama Risk-Based Corrective Action Guidance Manual, April 2008).

Worksheet 15.4: Project Action Limits and Laboratory Specific Limits for Groundwater Mobile On-Site Laboratory (Columbia Technology)

Analyte	CAS Number	Screening Criteria			Project Screening Criteria	Laboratory Specific Limits		
		USEPA MCL	USEPA RSL Tap Water	ADEM PSV		LOQ	LOD	MDL
Analytical Group: Volatile Organic Compounds by EPA Method SW8260B in µg/L								
Tetrachloroethene	127-18-4	5	4.1	5	4.1	1.33	0.50	0.22
Trichloroethene	79-01-6	5	0.28	5	0.28	1.31	1.0	0.26

Notes:

MCLs - Maximum Contaminant Level (USEPA, April 2012).
RSL - Regional Screening Level
NS - No Standard
RSL - Regional Screening Level for tap water, based on risk of 10-6 for carcinogens and HQ of 0.1 for noncarcinogens (June 2015).
MCLs shown for chloride, manganese, and sulfate are Secondary Drinking Water Regulations.
MCLs for bromodichloromethane, bromoform, chloroform, and dibromochloromethane are based on the 1998 Final Rule for Disinfectants and Disinfection By-Products: The total for trihalomethanes is 80 µg/L.
ADEM PSV - Alabama Department of Environmental Management Preliminary Screening Value is the MCL, if available; otherwise, it is the RSL (June 2015)(based on guidance outlined in the Alabama Risk-Based Corrective Action Guidance Manual, April 2008).

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WORKSHEET #16: PROJECT SCHEDULE/TIMELINE TABLE

See attached Schedule in Appendix C.

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WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

Worksheet #17 describes the rationale for choosing the project sampling approach and analysis. The sampling approach is designed based on the three mobilizations:

- Mobilization #1: Brush Clearing and Monitoring Well Groundwater Inventory and Sampling Event #1
- Mobilization #2: Soil and Groundwater Supplemental Data Gap Investigation
- Mobilization #3: Monitoring Well Groundwater Sampling Event #2

The sampling design and rationale for each of these field tasks includes the following: the matrices to be sampled; analytical groups and concentration levels; sample locations; and number of samples and frequency. The sampling design and analysis will be used to support the development of a baseline human health risk assessment and screening level ecological risk assessment. This in turn will be used to re-evaluate the remedial options as outlined in the FS (provide reference)

The following sections present the field sampling and analysis plan to refine the extent of soil and groundwater contamination which will be used in anticipation of future installation of permanent monitoring wells. Appendix B contains SOPs for the activities described in Worksheet #17.

17.1 Mobilization #1

The activities to be performed during the first mobilization will be used to assess the current conditions of the groundwater in order to develop groundwater sampling locations in the second mobilization. The first mobilization will consist of brush clearing, groundwater sampling, and well inventory of the monitoring wells.

17.1.1 Brush Clearing

Heavy brush will need to be cleared to get to each monitoring well location and to clear room to conduct the field sampling of soil and groundwater. A skid-steer with forestry mulcher will be required to remove the vegetation. Grasses and soft vegetation can be flattened. Woody vegetation such as trees and shrubs may be shredded/chipped and spread onsite or removed and disposed offsite. Vegetation from clearing activities cannot be left piled in any area. The brush clearing will be up to the fence line. Hand clearing around wells may be necessary to gain access and along the fence line. The large permanent trees will remain and not be cleared.

Caution should be taken around well locations OMS-28-4, OMS-28-5, and MW-9 as these wells are PVC stick-ups only with no steel cover or bollards. The monitoring wells should be located prior to clearing to ensure the wells are protected during clearing activities. Wells MW-8, OMS-28-6, and OMS-28-7 (located inside the fence on OMS property where vehicles are parked) are covered with gravel and dirt. Wells OMS-28-1 and MW-12 (located on the Interstate exit right of way) are covered in thatch. The wells are flush mounted and hand digging equipment to dig/clear them out to reach the well cover/pad will be required.

Approximately 1.95 acres will need to be cleared to allow for access. The area to be cleared in highlighted on **Figure 4**.

17.1.2 Monitoring Well Development

The total depths of monitoring wells MW-8, OMS-28-6, OMS-28-7, OMS-28-1, and MW-12 will be measured to determine if the wells contain sediment that needs to be removed. If the wells contain too much sediment, the wells will be re-developed/rehabilitated.

Well development will be performed using the pumping/overpumping and surging methods. This method shall be continued until the water is free from suspended sand-sized sediment. Following this process, the rate of overpumping shall be reduced to that of well sampling (0.5 liters per minute or one gallon in approximately 7.5 minutes). During this stage of development pH, specific conductivity, and turbidity will be measured until stability is achieved as specified in Section 17.1.3. Water exiting the well will be contained in 55-gallon Department of Transportation (DOT) rated drums and managed as described in Section 17.5. The Monitoring Well Development Log to be used is provided in **Appendix A** of this UFP-QAPP. Well development will be in accordance with the *AEIRG* (ADEM, 2005; Appendix B) and *USEPA Region 4 Operating Procedure Design and Installation of Monitoring Wells SESDGUID-101-R1* (USEPA, 2013a; Section 2.7). The SOPs are provided in **Appendix B** of this UFP-QAPP.

17.1.3 Well Inventory and Monitoring Well Sampling

17.1.3.1 Well Inventory

During the first groundwater sampling event, the field team will record the physical condition of each well on the Well Maintenance Form (**Appendix A**). **Figure 5** provides the monitoring well network at the Site. The following information will be recorded during each well inspection:

- Record the site and well number.
- Record the date and time of the inspection.
- List all field personnel performing the inspection.
- Indicate if the well was located or not located.
- Record the well casing diameter.
- Measure and record the total well depth.
- Record the condition of the well cap. Note if cap was replaced.
- Is a lock present? If so, is it in good working condition? If not, was the lock replaced?
- Is a well tag present? If so, record all information from the tag.
- Record the condition of the well pad, vault or protective casing, and protective posts (if applicable).
- Record any additional comments and/or observations.

The field team will determine the overall condition of the well, usable or not usable, based on field observations. Photographs of each well will be taken to visually show the well integrity. All well inspections will be included in the Well Inventory Report. A table will be provided in the Supplemental Data Gap Investigation Report summarizing the well inventory, including well construction information.

17.1.3.2 Groundwater Sampling

Water-Level Measurements

Water levels will be collected at each well that is to be sampled in accordance with the *AEIRG* (ADEM, 2005; Appendix C) and *USEPA Region 4 Operating Procedure Groundwater Level and Well Depth Measurement SESDPROC-105-R2* (USEPA, 20013b). Both guidance documents are provided in **Appendix B** of this UFP-QAPP.

Static depth to groundwater will be measured with an electronic water level meter. All well water levels will be collected from the top of casing at the measuring point and recorded to the nearest 0.01 feet. If no measuring point is identified on the well casing, the water level will be measured from the top of casing on the north rim. Because more than one water level meter may be used, all water level meters will be calibrated by measuring the water level at one select well with each meter. One water level meter will be selected as the standard and the others will be normalized to the standard. Water levels will be recorded on a Water Level Form provided in **Appendix A** of this UFP-QAPP.

Purging and Sample Collection

All monitoring wells will be purged before taking samples in order to ensure that water removed for analysis is representative of the true water quality in the aquifer. Wells may be purged using a peristaltic or electric/portable submersible. Prior to initiating the purge, the water column length will be determined in accordance with *AEIRG* (ADEM, 2005; Appendix C) and *Groundwater Sampling SESDPROC-301-R3* (USEPA, 2013c). Each well will be purged immediately prior to sampling. Purging will be accomplished using the low flow/low volume method in accordance with *AEIRG* (ADEM, 2005; Appendix C) and *Groundwater Sampling SESDPROC-301-R3* (USEPA, 2013c) and water level measurements will be collected during the purging process to ensure minimal or stable drawdown of the water column during purging is being met. This method is preferable in order to reduce the amount of purged water produced. If this condition cannot be met, traditional multiple volume purging will be conducted in accordance with *AEIRG* (ADEM, 2005; Appendix C) and *Groundwater Sampling SESDPROC-301-R3* (USEPA, 2013c).

The well will be considered adequately purged when the chemical parameters (pH and specific conductivity) have reached stability and turbidity is below 10 Nephelometric Turbidity Units (NTUs) or has stabilized within 10 percent. According to *Groundwater Sampling SESDPROC-301-R3* (USEPA, 20013c), temperature is no longer used for determining stability because it is subject to rapid changes when collected for measurement. Although it is no longer used to determining stability, temperature will continue to be recorded along with DO, oxidation reduction potential (ORP), and salinity. Stabilization occurs when for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit and specific conductance varies no more than approximately 5 percent. All chemical parameters except turbidity will be conducted using a flow through cell and YSI multi-meter (or equivalent). Turbidity will be measured using a HF Scientific Micro TPW (or equivalent). All equipment will be calibrated at the beginning of each day prior to use and recorded on the Calibration Log (**Appendix A**).

An initial set of groundwater chemistry parameters will be collected upon commencement of purging activities, with a set of parameters measured based on one equipment volume divided by the flow rate (typically every 3 to 5 minutes) or after each well volume has been removed depending on the purge method used. All purging and sampling activities will be documented on a Groundwater Sampling Log (**Appendix A**).

Monitoring well purging will be accomplished by using either a peristaltic pump and drop-down tubing with a check-valve attachment or electrical submersible pump with control. The pump intact will be lowered into the well and placed at the screen mid-point. If the well screen brackets the water table, at least one well volume will be removed during purging prior to collection of the stabilization parameters. If the well screen is completely submerged below the water table, at least one equipment volume will be removed prior to the collection of the first stabilization parameter, with a minimum of three equipment volumes to be removed before sampling.

To determine the volume of water standing in the well, use the following formula:

$$V = 0.041\ d^2\ h$$

where: h = water column depth (feet) [well depth - depth to water]

d = diameter of well (inches)

V = volume of water (gallons)

The volume calculations for some common well diameters are presented below:

1.5” diameter	V = 0.09225h,
2” diameter	V = 0.164h
4” diameter	V = 0.656h
6” diameter	V = 1.476h

Prior to collecting the groundwater sample, the flow-through cell will be removed from the circuit. For the collection of VOCs, the “soda straw” method will be used (USEPA, 2013c). The samples will be shipped to GCAL and analyzed for TCL VOCs by Method 8260B on a 5-day turnaround time.

17.2 Mobilization #2

The activities to be performed during the second mobilization will be used to determine new/refine existing soil source area and to refine horizontal and vertical delineation of groundwater plume. MIP and HPT will initially be used as a field screening tool and samples will be collected via DPT to characterize the soil and groundwater. This information, along with, historical data will be used to re-evaluate the remedial alternative presented in the FS and as part of the risk assessment.

17.2.1 Utility Location

A geophysical survey will be conducted to verify if proposed borehole locations are clear of underground utilities and subsurface anomalies. The geophysical survey will include initiating the One-call process (Alabama Line Locators) and performing a utility clearance. MAA and private property owners will also be notified when subsurface investigation activities are to be performed.

The One-call process will be initiated with the Utility Notification Center (Alabama Line Locators: Alabama 811) to notify utility companies that intrusive activities will be performed at each site. Representatives of local utility companies shall identify and mark underground utilities, if present.

A utility clearance survey will be conducted to locate and mark underground utilities and subsurface anomalies. The locations of underground utilities identified by local utility companies will be confirmed and the clearance will identify other underground utilities, if present, using geophysical surveying equipment. Geophysical surveying equipment may include a utility pipe locator, ground penetrating radar, and/or surface magnetometer. Utilities and subsurface anomalies will be marked. Proposed sampling locations adjacent to underground utilities will be relocated at least 5 feet away.

17.2.2 MIP / HPT

Soil source characterization will begin with the LLMIP/EC probe to identify concentrations of contaminants in soil that may be contributing to groundwater contamination. LLMIP is also recommended within the higher concentration portion of the existing groundwater plume, specifically at depths deeper than the existing shallow well network based on the idea that PCE and TCE will sink to lower depths.

At each location, the DPT will advance the LLMIP probe in one-foot intervals and the LLMIP detector will collect soil vapor samples for screening. VOCs in the subsurface diffuse across the LLMIP membrane and partition into a stream of carrier gas where they are screened using a PID, a flame ionization detector (FID), and a halogen specific detector.

The HPT tool will be used for hydrostratigraphic screening to determine hydraulic conductivity of the aquifer for development of treatment alternatives. Both the MIP and HPT will be advanced to a depth of 35-feet bgs or top of the clay confining unit. The LLMIP and HPT borings will need to be separate borings due to the speed required for the push rates. Due to the low concentrations in the study areas, the MIP is only recommended in the source area due to its limitation of detecting total VOC concentrations down to 0.5 part per million.

The HPT probe will continually inject small amounts of water and use pressure response measurements to provide real time profiles of soil hydraulic properties. A low pressure response indicates a zone of high hydraulic conductivity such as a sandy zone where contaminant migration may be occurring. The EC probe provides soil classification by measuring the soil conductivity and resistivity. In general, silts and clays exhibit higher electrical conductivity readings than sands and gravels. In addition, the DPT will be used to collected continuous soil samples to the top of the clay confining layer (approximately 35 feet bgs) for visual soil classification and comparison to the HPT data. Continuous core samples will also be collected for visual inspection via DPT for comparison to the HPT data and will be described using the Unified Soil Classification System (USCS).

The initial proposed LLMIP/HPT/EC boring locations are shown on **Figure 6**. Initial LLMIP locations were selected within the known soil source areas for confirmation and in the higher concentration portion of the dissolved groundwater plume for vertical profiling to the top of the clay confining layer as wells are only screening in the upper portion. In addition, LLMIP locations have been identified around the former washpad and former pollution control system as potential additional sources that have not previously been investigated. If the LLMIP detection is positive, step-out locations approximately 30-feet in each direction will be identified for additional LLMIP until no detection of total VOCs is achieved. HPT locations have been distributed throughout the dissolved plume to provide hydrogeologic information for design of remedial alternatives.

All boreholes will be grouted at the conclusion of the MIP / HPT event.

17.2.3 DPT Soil and Groundwater Sampling

Soil Samples

Soil sampling will be conducted in accordance with *AEIRG* (ADEM, 2005; Appendix C) and *USEPA's Operating Procedure for Soil Sampling SESDPROC-300-R2* (USEPA, 2011a). Both guidance documents are provided in **Appendix B**. The initial soil sample locations are provided on **Figure 7**. These locations are based on historical data and previously known source locations. However, review of historical data indicates the outer limits of the soil source areas are not defined. Further soils sampling is recommended along round the former washpad and former pollution control system which may be a potential source that was not previously identified. Additional locations may be required based on the initial soil sample location results and the LLMIP results.

Soil boring locations are based on MIP/HPT/EC results from depths suspected to be a source. The DPT will use a macro-core sampling devise inside an outer drill casing. The outer drill casing will advance the borehole to the desired depth. The 2-inch macro-core sampling device will then be advanced to collect a 4-foot long soil core sample inside an acetate liner. Continuous soil cores will be collected to the groundwater table and screened at 2-foot intervals with a PID and the lithology will be described using the USCS. From each soil core, samples will be collected from a maximum of three depths:

- surface soil (0-1 foot),
- areas of highest VOC concentration, and
- 1-foot above the soil/water interface.

Terra Core® samplers will be used to collect samples for analysis of VOCs in soil. The Terra Core is a one-time use transfer tool, designed to easily take soil samples and transfer them to the appropriate containers for in-field chemical preservation. The VOC sample will be collected using the sampling tool at the targeted interval.

Soil samples will be sent to the on-site mobile laboratory (Columbia Technologies) for analysis of TCE and PCE by Method 8260B. Splits soil samples will be collected (10%) and sent to an off-site fixed laboratory (GCAL) for QC to be analyzed for TCL VOCs by Method 8260. Field duplicate samples (10%) and MS/MSD (5%) will be collected and sent to the mobile laboratory (Columbia Technologies) for analysis. Equipment blanks are not necessary because all sampling equipment will be disposable and not reused.

Groundwater Samples

Groundwater grab samples will be collected using the DPT with a screen point sampler in order to characterize the horizontal and later extent of groundwater contamination. Groundwater samples will be collected through a screen point sampler using a peristaltic pump. As groundwater is allowed to flow into the sampler, a peristaltic pump and polyethylene tubing will be used to withdraw a groundwater screening sample. One equipment volume will be purged prior to sample collection. The “soda straw” method will be used (USEPA, 2013c) as discussed in Section 17.1.3. Water quality parameters DO, ORP, temperature, pH, conductivity, and salinity will be collected for each groundwater grab samples and recorded on Groundwater Sampling Log (**Appendix A**).

Locations and depths will be based on the groundwater sample results from the first mobilization and the LLMIP results. Initial groundwater sample locations are proposed on **Figure 8** based on the 2010 plume configuration. Additional step-out samples (30-feet step-outs) may be required to refine the groundwater plume boundary. From each groundwater borehole locations, samples will be collected from a maximum of three depths:

- Water Table,
- Highest LLMIP interval or mid-way between the top of the water table and the top of the clay confining layer (approximately 18-23 feet bgs), and
- The bottom of the surficial aquifer above the confining layer, approximately 30-35 feet bgs.

Groundwater grab samples will be analyzed by the on-site mobile laboratory (Columbia Technologies) for analysis of TCE and PCE by Method 8260B. Splits groundwater samples will be collected (10%) and sent to an off-site fixed laboratory (GCAL) for QC to be analyzed for TCL VOCs by Method 8260. Field duplicate samples (10%) and MS/MSD (5%) will be collected and sent to the mobile laboratory (Columbia Technologies) for analysis. Equipment blanks are not necessary because all sampling equipment will be disposable and not reused.

All boreholes will be grouted at the conclusion of the DPT event.

17.2.4 GPS Survey

A hand-held GPS unit will be used to survey soil-borings, groundwater grab sample, and MIP/HPT locations. These GPS locations will be used for creating figures for the reports. All GPS activities will be in accordance with the USEPA operating procedure for *Global Positioning System SESDPROC-110-R3* (USEPA, 2011b).

17.3 Mobilization #3

The third mobilization will consist of monitoring well groundwater sampling to be conducted approximately one year from the groundwater sampling performed as part of the first mobilization. The same procedures as performed during the first mobilization for monitoring well groundwater sampling (Section 17.1.3) will be performed during the third mobilization. The samples will be analyzed for TCL VOCs by Method 8260B and be analyzed by GCAL on a standard turnaround time.

17.4 Decontamination

When practical and economically feasible, disposable equipment will be used. Any non-disposable equipment used will be decontaminated prior to each use. Decontamination will consist of cleaning with tap water and Liquinox® (or equivalent) detergent using a brush to remove particulate matter and surface fines, and then rinsed thoroughly with tap water and then rinsed with de-ionized water.

The stainless steel equipment will be allowed to air dry before wrapping in aluminum foil. All tubing will be disposed of after one use and will not require decontamination.

Decontamination of heavy equipment such as DPT rigs will be in accordance with the *AEIRG* (ADEM, 2005; Appendix E) and USEPA's operating procedure *Field Equipment Cleaning and Decontamination SESDPROC-205-R2* (USEPA, 2011c), which are included in Appendix B of this UFP-QAPP. All down-hole equipment will be decontaminated between each borehole to avoid the potential for cross contamination between water bearing zones or areas of the site. All decontamination fluids will be contained for investigative derived waste (IDW) disposal.

17.5 IDW Management

IDW management activities will be conducted to properly stage IDW, appropriately manage IDW, and characterize IDW for disposal. Sources of IDW will include soil cuttings, well development water, well purge water, and decontamination fluids. During field investigation, activities, waste minimization practices will be implemented to the extent practical. Wastes such as consumable materials, supplies, and equipment will be cleaned, as necessary, and disposed of as municipal trash.

IDW will be appropriately managed beginning at the time of generation to disposal. An IDW staging area will be identified for drum storage and placed on wooden pallets. Drum staging areas will be identified and coordinated with the FMS-28 Chief, as applicable. All liquid IDW will be contained in 55-gallon DOT rated drums. Each drum will be identified with a written label on the top and side of the drum. In addition, a drum inventory log will be maintained. Immediately after collecting soil samples, soil IDW (contents of the DPT soil sampling) will be placed on plastic sheets near the DPT boring locations from which it was derived. Pending the results from the mobile, on-site laboratory, the soil will be either placed back in the borehole from which is was derived if concentrations of analytes are below residential and industrial RSLs (see Worksheet #15.2) or contained in DOT rated 55-gallon drums and labeled accordingly.

IDW will be characterized for disposal by evaluating environmental sampling data. If environmental sampling data are insufficient to characterize IDW for disposal, waste characterization samples will be collected. IDW will be removed and transported to an appropriate disposal facility within 90 calendar days of completing the field activities which generated the IDW. IDW may not remain onsite between mobilizations. The ALARNG point of contact shall sign all waste manifests for the waste disposal.

WORKSHEET #18: LOCATION-SPECIFIC SAMPLING METHODS/SOP REQUIREMENTS TABLE

Mobilization	Matrix		Sample Location ID	Depth Estimated bgs (feet)	Analytical Group	Number of Samples	Sampling SOP Reference
Mob #1	Groundwater Wells		MW-5	13.6	TCL VOCs and Quality Control (Fixed Lab)	12 primary samples 1 duplicates, 1 MS/MSD, trip blanks (1 per cooler)	AEIRG / US EPA SESDPROC-301-R3 (Appendix B)
			MW-6	12.7			
			MW-8	15.2			
			MW-9	17.4			
			MW-12	15.6			
			OMS-28-1	80.0			
			OMS-28-2	20.0			
			OMS-28-3	20.0			
			OMS-28-4	76.0			
			OMS-28-5	20.0			
			OMS-28-6	76.0			
			OMS-28-7	20.0			
			OMS-28-3-a	20.0			
			OMS-28-7-ms	20.0			
			OMS-28-7-msd	20.0			
Mob #2	Soil	Surface Soil Field Screening	OMS-28-SB01-01 through OMS-28-SB-23-01	0 – 1 foot	PCE and TCE and Quality Control (Mobile Lab)	120 primary samples 12 duplicates, 6 MS/MSD	AEIRG / US EPA SESDPROC-300-R2 (Appendix B)
		Surface Soil Confirmatory	OMS-28-SB01-01-s through OMS-28-SB-23-01-s (specific identification to be assigned in the field based on percentage of samples)	0 – 1 foot	TCL VOCs and Quality Control (Fixed Lab)	12 primary samples (duplicates of field screening) 1 duplicates and 1 MS/MSD	

Mobilization	Matrix		Sample Location ID	Depth Estimated bgs (feet)	Analytical Group	Number of Samples	Sampling SOP Reference
	Groundwater Grab	Field Screening	OMS-28-GW01-16 through OMS-28-GW50-16	Water Table appx 12-16	PCE and TCE and Quality Control (Mobile Lab)	135 samples 14 duplicate, 7 MS/MSD	AEIRG / US EPA SESDPROC-301-R3 (Appendix B)
			OMS-28-GW01-25 through OMS-28-GW50-28	Mid-point between water table and top of clay appx 21-25			
			OMS-28-GW01-34 through OMS-28-GW50-34	Top of Clay approx. 30-34			
		Confirmatory	OMS-28-GW01-TBD-s through OMS-28-GW50-TBA-s (specific identification to be assigned in the field based on percentage of samples)	Water Table appx 12-16	TCL VOCs and Quality Control (Fixed Lab)	14 primary samples (duplicates of field screening) 1 duplicate, 1 MS/MSD, trip blanks (1 per cooler)	
				Mid-point between water table and top of clay appx 21-25			
				Top of Clay approx. 30-34			

Mobilization	Matrix	Sample Location ID	Depth Estimated bgs (feet)	Analytical Group	Number of Samples	Sampling SOP Reference
Mob #3	Groundwater Wells	MW-5	13.6	TCL VOCs and Quality Control (Fixed Lab)	12 samples 1 duplicates, 1 MS/MSD, trip blanks (1 per cooler)	AEIRG / US EPA SESDPROC-301-R3 (Appendix B)
		MW-6	12.7			
		MW-8	15.2			
		MW-9	17.4			
		MW-12	15.6			
		OMS-28-1	80.0			
		OMS-28-2	20.0			
		OMS-28-3	20.0			
		OMS-28-4	76.0			
		OMS-28-5	20.0			
		OMS-28-6	76.0			
		OMS-28-7	20.0			
		OMS-28-3-a	20.0			
		OMS-28-7-ms	20.0			
		OMS-28-7-msd	20.0			

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WORKSHEET #19: FIELD SAMPLING REQUIREMENTS TABLE

Worksheet #19.1: Analytical SOP Requirement for Fixed Off-Site Laboratory

Matrix	Analytical Group	Sample Preparation and Analytical Method / SOP Reference	Container	Preservative	Maximum Holding Times	
					Extraction	Analysis
Aqueous	TCL VOCs	EPA Method SW5030B/SW8260B SOP GCMSV-003 Rev.27	3 x 40 mL G, Septa vial Teflon-lined septum sealed cap	Ice to 4°C HCl pH <2	Not Applicable (N/A)	14d
Soil	TCL VOCs	EPA Method SW5030B/SW8260B SOP GCMSV-003 Rev.27	Terra Core®	Ice to 4°C NaHSO4(2), MeOH(1)	N/A	14d

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Worksheet #19.2: Analytical SOP Requirement for Mobile On-Site Laboratory

Matrix	Analytical Group	Sample Preparation and Analytical Method / SOP Reference	Container	Preservative	Maximum Holding Times	
					Extraction	Analysis
Aqueous	VOCs (PCE and TCE)	CT-EXT-001(EPA Method 5030)/CT-ORG-001 (EPA Method 8260)	40mL VOA vial	HCl or none	7 days without preservation, 14 with preservation	7 days without preservation, 14 days with preservation
Soil	VOCs (PCE and TCE)	CT-EXT-002 (EPA Method 5035)/-ORG-001 (EPA Method 8260)	2 oz glass jar	sodium bisulfate or none	48 hours without preservation, 7 days with preservation,	48 hours without preservation, 7 days with preservation

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WORKSHEET #20: FIELD QUALITY CONTROL SAMPLE SUMMARY TABLE

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates [a]	No. of MS/MSDs [a]	No. of Trip Blanks	Total No. of Samples to Lab
Soil	VOCs (PCE and TCE only)	120	12	6	N/A	138
	TCL VOCs	12	1	1	N/A	14
Groundwater	VOCs (PCE and TCE only)	135	14	7	N/A – Mobile Lab	156
	TCL VOCs	38	4	2	11	55

[a] Quality control samples will be collected at frequencies identified in Worksheet #12.
N/A – not applicable

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WORKSHEET #21: PROJECT SAMPLING SOP REFERENCES TABLE

Reference Number	Title, Revision Date and / or Number [a]	Originating Organization of Sampling SOP	Field Equipment Type	Modified for Project Work? (Yes/No)
N/A	Alabama Environmental Investigation and Remediation Guidance / September 2005	ADEM	Water quality parameter instrument and peristaltic or submersible pump / PID	No
SESDPROC-105-R2	Groundwater Level and Well Depth Measurement / January 2013	USEPA Region 4	Water Level Meter	No
SESDPROC-301-R3	Groundwater Sampling / March 2013	USEPA Region 4	Water quality parameter instrument and peristaltic or submersible pump	No
SESDPROC-300-R2	Soil Sampling / December 2011	USEPA Region 4	PID	No
SESDPROC-201-R1	Surface Water Sampling	USEPA Region 4	Water quality parameter instrument	No
SESDPROC-110-R3	Global Positioning System	US EPA Region 4	GPS Unit	No
Technical Bulletin MK3010	Geoprobe Mebrane Interface Probe (MIP) / January 2015	Geoprobe Systems, Inc.	Membrane Interface Probe Direct Sensing Technology	No
N/A	Geoprobe Low Level MIP SOP / May 2014	Geoprobe Systems, Inc.	Low Level MIP Direct Sensing Technology	No
Technical Bulletin MK3137	Geoprobe Hydraulic Profiling Tool (HPT) System / January 2015	Geoprobe Systems, Inc.	Hydraulic Profiling Tool Direct Sensing Technology	No

N/A – not applicable.

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WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION TABLE

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]
PID Meter	Calibrate with ambient air and a calibration span gas (100 parts per million isobutylene).	Keep batteries charged.	Test with ambient air or calibration gas.	Visually inspect meter for wear or damage before calibration.	Daily	Stable and acceptable readings achieved per manufacturer's instructions.	If readings do not stabilize, do not use device.	Field Manager	SESDPROC-300-R2, AEIRG, and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Water Quality Parameter Instrument	Calibrate with calibration solutions (pH buffers and conductivity and turbidity solutions).	Decontaminate after every use. Keep batteries charged.	Test with calibration solutions.	Visually inspect probes for wear or damage. Run a calibration.	Daily	Stable readings achieved (three or more successive readings within 10% of each other).	If readings do not stabilize, do not use device.	Field Manager	SESDPROC-301-R3, AEIRG, and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Peristaltic or submersible pump and assembly	-	Decontaminate pumps between wells and dispose of tubing.	Determine if pumps are working correctly. Adjust flow rate (purge rate) to yield 100 - 300 milliliters per minute. Operate at low flow for several minutes.	Visually inspect for damage.	Daily	Pump is not creating significant draw-down (i.e., ≤ 0.2 feet).	Reduce pumping rate and continue to monitor draw-down with water level meter until acceptance criterion is met.	Field Manager	SESDPROC-301-R3, AEIRG, and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Water Level Meter	Normalize to one well at beginning of each event	Decontaminate tape between wells	Determine if meter is working correctly. Adjust sensitivity.	Visually inspect tape for damage.	Daily	Sounding at water table interface	Return to manufacture for maintenance	Field Manager	SESDPRO-105-R2, AEIRG, and manufacturer's specifications for all inspection, testing, maintenance, and calibrations

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[a]
GPS Unit	Prior to survey, verify vs. previously surveyed location (e.g., benchmark).	Visual inspection.	Check daily vs. position established during field sampling or previously surveyed location.	Check daily.	Daily	≤ 10 feet	Return to manufacturer for recalibration.	Field Manager	SESDPROC-110-Rs and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
LLMiHPT	N/A	Decontamination after every use	Test before and after each location using the headspace of neat, site-specific standards to evaluate the sensitivity of the particular probe, transfer line and detector suite to be used.	Visually inspect the transfer line for cracks, tears and wear before and after each location.	Before and after each location	Accepted readings compared to predetermined values	If any of the above tests or inspections fail, start troubleshooting procedures per the SOP	Field Geochemist	Geoprobe SOP for MIP, LLMIP and HPT

[a] Reference number from the Project Sampling SOP References table (Worksheet #21).
SOPs are attached in Appendix B

WORKSHEET #23: ANALYTICAL SOP REFERENCES TABLE

Worksheet 23.1 Analytical SOP References Table for Fixed Off-Site Laboratory (GCAL)

SOP Reference	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis (name and address)	Modified for Project Work? (Y/N)
Preparation Method/SOP Reference						
GCMSV-003	ANALYSIS OF VOCs BY GC/MS EPA 8260B (Revision 27, Effective 09/17/15)	Definitive	Aqueous TCL VOCs	GC/MS	GCAL	N
GCMSV-003	ANALYSIS OF VOCs BY GC/MS EPA 8260B (Revision 27, Effective 09/17/15)	Definitive	Soil TCL VOCs	GC/MS	GCAL	N

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Worksheet 23.2 Analytical SOP References Table for Mobile On-Site Laboratory (Columbia Technology)

SOP Reference	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis (name and address)	Modified for Project Work? (Y/N)
Preparation Method/SOP Reference						
CT-ORG-001	PCE and TCE	Definitive	Aqueous PCE and TCE	GC/MS	Columbia Technologies	N
CT-ORG-001	PCE and TCE	Definitive	Soil PCE and TCE	GC/MS	Columbia Technologies	N

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WORKSHEET #24: ANALYTICAL INSTRUMENT CALIBRATION TABLE

Worksheet 24.1 Analytical Instrument Calibration Table for Fixed Off-Site Laboratory (GCAL)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Personnel Responsible for Corrective Action	SOP Reference
GC/MS	Check of mass tuning	Prior to IC and at the beginning of each 12-hour period	Values for masses 69, 219, and 264 (if using PFTBA) within ± 0.50 amu of the target mass	Retune instrument and verify.	Analyst	GCMSV-003
GC/MS	Minimum five-point initial calibration for target analytes, lowest concentration standard at or near the reporting limit. (IC)	Initial calibration prior to sample analysis	a) RSD for each analyte ≤ 15%; or b) linear least squares regression r ≥ 0.995; or c) non-linear regression COD r^{-} ^{sq2} ≥ 0.99, min 6 points for second order	Correct problem, then repeat initial calibration.	Analyst	GCMSV-003
GC/MS	Second-source calibration verification	Once after each IC	All project analytes within ± 20% of true value	Correct problem, and verify second source standard. Rerun verification. If still fails, repeat initial calibration.	Analyst	GCMSV-003
GC/MS	Retention Time Window Position Establishment	Once per IC, for each analyte and surrogate	Set position using the mid-point standard of the IC when IC is performed. On days when IC is not performed, use initial CCV	N/A	N/A	GCMSV-003
GC/MS	Daily calibration verification	Daily, prior to sample analysis and every 12 hours of analysis time	%Difference for all target compounds and surrogates: %Difference ≤ 20%	Correct problem, then repeat. If still fails, repeat initial calibration. Reanalyze all samples since last successful calibration verification.	Analyst	GCMSV-003
GC/MS	Internal Standards	During acquisition of calibration standard	Areas within -50% to +100% of last IC mid-point for each CCV	Inspect MS and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Analyst	GCMSV-003
ICP/MS	With a minimum of three standard and a calibration blank	Initial calibration prior to sample analysis	Correlation coefficient >0.995	Correct problem, then repeat initial calibration.	Analyst	MET-021
ICP/MS	Percent recovery of standards	Daily, after calibration	Within ±25% (± 50% for the lowest concentration standard) of the true value for all target analytes	Correct problem, then repeat. If still fails, repeat initial calibration.	Analyst	MET-021

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Personnel Responsible for Corrective Action	SOP Reference
ICP/MS	Second-source ICV, prepared at the calibration midpoint	Once per initial calibration	Within ±15% of the true value for all target analytes	Correct problem, then repeat. If still fails, repeat initial calibration.	Analyst	MET-021
ICP/MS	CCV, same source as IC	Following IC, after every 10 samples and the end of the sequence	Within ±10% of the true value for all target analytes	Correct problem, then repeat. If still fails, repeat initial calibration. Re-analyze all samples since the last successful calibration verification.	Analyst	MET-021
GC/TCD/FID	Minimum five-point initial calibration for target analytes, lowest concentration standard at or near the reporting limit	Initial calibration prior to sample analysis	One of the options below: 1) RSD for each analyte ≤ 20%; 2) Linear least squares regression: r ≥ 0.995; 3) non-linear regression: COD (r2) ≥ 0.99, minimum of 6 points for second order.	Correct problem, then repeat initial calibration.	Analyst	GCV-024
GC/TCD/FID	Retention Time Window Position Establishment	Once per initial calibration, for each analyte and surrogate	Set position using the mid-point standard of the initial calibration when initial calibration is performed. On days when initial calibration is not performed, use initial CCV.	N/A	N/A	GCV-024
GC/TCD/FID	Second-source calibration verification	Immediately following initial calibration	All project analytes within ± 20% of the expected value from the initial calibration.	Correct problem, then repeat. If still fails, repeat initial calibration.	Analyst	GCV-024
GC/TCD/FID	Daily calibration verification	Prior to sample analysis, after every 10 field samples, and at the end of the sequence	All project analytes within ± 20% of the expected value from the initial calibration.	Correct problem, then repeat. If still fails, repeat initial calibration. Re-analyze all samples since the last successful calibration verification.	Analyst	GCV-024
Mettler Toledo DL53 Autotitrator	Calibration of pH buffers 4, 7 and 10	Daily before use	Slope is -52 to -65	Correct problem, then repeat initial calibration.	Analyst	WL-063
IC	Initial calibration per manufacturer's instructions, with a minimum of five standards and a	Initial calibration prior to sample analysis	Correlation coefficient >0.995; accepted if the ICV passes.	Correct problem, then repeat initial calibration.	Analyst	WL-042

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Personnel Responsible for Corrective Action	SOP Reference
IC	Second-source ICV, prepared at the calibration midpoint	Once per initial calibration	Less than 10% difference from initial calibration for all target analytes.	Correct problem, then repeat. If still fails, repeat initial calibration.	Analyst	WL-042
IC	CCV, same source as initial calibration	Following initial calibration, after every 10 samples and the end of the sequence	Less than 10% difference from initial calibration for all target analytes.	Correct problem, then repeat. If still fails, repeat initial calibration. Re-analyze all samples since the last successful calibration verification.	Analyst	WL-042
Shimadzu TOC	Minimum three-point initial calibration and calibration blanks	Initial calibration prior to sample analysis	Correlation coefficient >0.995	Correct problem, then repeat initial calibration.	Analyst	WL-043
Shimadzu TOC	CCV	Beginning of batch if no ICAL, every ten samples and at the end of the analytical sequence 50	Recovery of 90-110%	Repeat ICAL and reanalyze all samples analyzed since the last successful calibration verification	Analyst	WL-043
Shimadzu TOC	ICV	Once after ICAL	All analytes within +/- 10% of expected value.	Remake standard, recalibrate if necessary.	Analyst	WL-043

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Worksheet 24.2 Analytical Instrument Calibration Table for Mobile On-Site Laboratory (Columbia Technology)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Personnel Responsible for Corrective Action	SOP Reference
GC/MS	Check of mass tuning	Prior to IC and at the beginning of each 12-hour period	Values for masses 69, 219, and 264 (if using PFTBA) within ± 0.50 amu of the target mass	Retune instrument and verify.	Analyst	CT-ORG-001
GC/MS	Minimum five-point initial calibration for target analytes, lowest concentration standard at or near the reporting limit. (IC)	Initial calibration prior to sample analysis	a) RSD for each analyte ≤ 15%; or b) linear least squares regression r ≥ 0.995; or c) non-linear regression COD r^{-sq2} ≥ 0.99, min 6 points for second order	Correct problem, then repeat initial calibration.	Analyst	CT-ORG-001
GC/MS	Second-source calibration verification	Once after each IC	All project analytes within ± 20% of true value	Correct problem, and verify second source standard. Rerun verification. If still fails, repeat initial calibration.	Analyst	CT-ORG-001
GC/MS	Retention Time Window Position Establishment	Once per IC, for each analyte and surrogate	Set position using the mid-point standard of the IC when IC is performed. On days when IC is not performed, use initial CCV	N/A	N/A	CT-ORG-001
GC/MS	Daily calibration verification	Daily, prior to sample analysis and every 12 hours of analysis time	%Difference for all target compounds and surrogates: %Difference ≤ 20%	Correct problem, then repeat. If still fails, repeat initial calibration. Reanalyze all samples since last successful calibration verification.	Analyst	CT-ORG-001
GC/MS	Internal Standards	During acquisition of calibration standard	Areas within -50% to +100% of last IC mid-point for each CCV	Inspect MS and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Analyst	CT-ORG-001
ICP/MS	With a minimum of three standard and a calibration blank	Initial calibration prior to sample analysis	Correlation coefficient >0.995	Correct problem, then repeat initial calibration.	N/A	N/A
ICP/MS	Percent recovery of standards	Daily, after calibration	Within ±25% (± 50% for the lowest concentration standard) of the true value for all target analytes	Correct problem, then repeat. If still fails, repeat initial calibration.	N/A	N/A

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Personnel Responsible for Corrective Action	SOP Reference
ICP/MS	Second-source ICV, prepared at the calibration midpoint	Once per initial calibration	Within ±15% of the true value for all target analytes	Correct problem, then repeat. If still fails, repeat initial calibration.	N/A	N/A
ICP/MS	CCV, same source as IC	Following IC, after every 10 samples and the end of the sequence	Within ±10% of the true value for all target analytes	Correct problem, then repeat. If still fails, repeat initial calibration. Re-analyze all samples since the last successful calibration verification.	N/A	N/A
GC/TCD/FID	Minimum five-point initial calibration for target analytes, lowest concentration standard at or near the reporting limit	Initial calibration prior to sample analysis	One of the options below: 1) RSD for each analyte ≤ 20%; 2) Linear least squares regression: r ≥ 0.995; 3) non-linear regression: COD (r2) ≥ 0.99, minimum of 6 points for second order.	Correct problem, then repeat initial calibration.	N/A	N/A
GC/TCD/FID	Retention Time Window Position Establishment	Once per initial calibration, for each analyte and surrogate	Set position using the mid-point standard of the initial calibration when initial calibration is performed. On days when initial calibration is not performed, use initial CCV.	N/A	N/A	N/A
GC/TCD/FID	Second-source calibration verification	Immediately following initial calibration	All project analytes within ± 20% of the expected value from the initial calibration.	Correct problem, then repeat. If still fails, repeat initial calibration.	N/A	N/A
GC/TCD/FID	Daily calibration verification	Prior to sample analysis, after every 10 field samples, and at the end of the sequence	All project analytes within ± 20% of the expected value from the initial calibration.	Correct problem, then repeat. If still fails, repeat initial calibration. Re-analyze all samples since the last successful calibration verification.	N/A	N/A
Mettler Toledo DL53 Autotitrator	Calibration of pH buffers 4, 7 and 10	Daily before use	Slope is -52 to -65	Correct problem, then repeat initial calibration.	N/A	N/A

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Personnel Responsible for Corrective Action	SOP Reference
IC	Initial calibration per manufacturer's instructions, with a minimum of five standards and a calibration blank	Initial calibration prior to sample analysis	Correlation coefficient >0.995; accepted if the ICV passes.	Correct problem, then repeat initial calibration.	N/A	N/A
IC	Second-source ICV, prepared at the calibration midpoint	Once per initial calibration	Less than 10% difference from initial calibration for all target analytes.	Correct problem, then repeat. If still fails, repeat initial calibration.	N/A	N/A
IC	CCV, same source as initial calibration	Following initial calibration, after every 10 samples and the end of the sequence	Less than 10% difference from initial calibration for all target analytes.	Correct problem, then repeat. If still fails, repeat initial calibration. Re-analyze all samples since the last successful calibration verification.	N/A	N/A
Shimadzu TOC	Minimum three-point initial calibration and calibration blanks	Initial calibration prior to sample analysis	Correlation coefficient >0.995	Correct problem, then repeat initial calibration.	N/A	N/A
Shimadzu TOC	CCV	Beginning of batch if no ICAL, every ten samples and at the end of the analytical sequence 50	Recovery of 90-110%	Repeat ICAL and reanalyze all samples analyzed since the last successful calibration verification	N/A	N/A
Shimadzu TOC	ICV	Once after ICAL	All analytes within +/- 10% of expected value.	Remake standard, recalibrate if necessary.	N/A	N/A

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WORKSHEET #25: ANALYTICAL INSTRUMENT AND EQUIPMENT MAINTENANCE, TESTING, AND INSPECTION TABLE

Worksheet 25.1 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table for Fixed Off-Site Laboratory (GCAL)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
GC/MS	Clean sources, maintain vacuum pumps	Tuning	Instrument performance and sensitivity	Service vacuum pumps twice per year, other maintenance as needed	Tune and CCV pass criteria	Recalibrate instrument	Analyst	GCMSV-003
GC/MS	Change septum, clean injection port, change or clip column, install new liner, change trap	Sensitivity check	Instrument performance and sensitivity	Daily or as needed	Tune and CCV pass criteria	Re-inspect injector port, cut additional column, reanalyze CCV, recalibrate instrument	Analyst	GCMSV-003
ICP/MS	Replace pump windings	Monitor ISTD counts for variation	Instrument performance and sensitivity	As needed	Monitor ISTD counts for variation	Replace windings, recalibrate and reanalyze	Analyst	MET-021
ICP/MS	Check instrument connections, gas flow, pressure	Conduct leak test	Visually inspect for wear or damage and indicator from computer controls	Daily and annual maintenance from manufacturer	Intensity of spectrum is within manufacturer's recommendation	Call for maintenance service	Analyst or certified instrument technician	MET-021
ICP/MS	Clean the torch in Aqua Regia solution and align the torch	Conduct leak test and adjust alignment	Inspect for leaks and align the torch and ensure that it is in the center	Each week (minimum every 2 weeks)	Torch is centered and no leaks	Replace or call for maintenance service	Analyst or certified instrument technician	MET-021
ICP/MS	Clean the chamber and nebulizer	N/A	Visually inspect for foreign objects	Each week	Make sure chamber and nebulizer are clean	Replace or call for maintenance service	Analyst or certified instrument technician	MET-021
GC/TCD/FID	Change septum, clean injection port, change or clip column, install new liner	Detector signals and chromatogram review	Instrument performance and sensitivity	As needed	CCV passes criteria	Re-inspect injector port, cut additional column, reanalyze CCV, recalibrate instrument	Analyst	GCV-024

Auto-Titrator	No maintenance activity	N/A	N/A	N/A	N/A	N/A	Analyst	WL-063
Instrument/ Equipment	**Maintenance Activity**	**Testing Activity**	**Inspection Activity**	**Frequency**	**Acceptance Criteria**	**Corrective Action**	**Responsible Person**	**SOP Reference**
IC	Check the interior of the main compartment for leaks or spills, isolate and repair leaks. Check the waste container daily and empty when needed	Sensitivity check	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	Analyst	WL-042
IC	Locate and replace any pinched or damaged lines. Check the junction between the pump head and the metal pump casting for evidence of liquid leaks. Normal friction and wear may gradually result in small liquid leaks around the piston seal. If leaks occur, replace the piston seals	Sensitivity check	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	Analyst	WL-042
TOC	No maintenance activity	N/A	N/A	N/A	N/A	N/A	Analyst	WL-043

Worksheet 25.2 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table Mobile On-Site Laboratory (Columbia Technology)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
GC/MS	Clean sources, maintain vacuum pumps	Tuning	Instrument performance and sensitivity	Service vacuum pumps twice per year, other maintenance as needed	Tune and CCV pass criteria	Recalibrate instrument	Analyst	CT-ORG-001
GC/MS	Change septum, clean injection port, change or clip column, install new liner, change trap	Sensitivity check	Instrument performance and sensitivity	Daily or as needed	Tune and CCV pass criteria	Re-inspect injector port, cut additional column, reanalyze CCV, recalibrate instrument	Analyst	CT-ORG-001
ICP/MS	Replace pump windings	Monitor ISTD counts for variation	Instrument performance and sensitivity	As needed	Monitor ISTD counts for variation	Replace windings, recalibrate and reanalyze	Analyst	N/A
ICP/MS	Check instrument connections, gas flow, pressure	Conduct leak test	Visually inspect for wear or damage and indicator from computer controls	Daily and annual maintenance from manufacturer	Intensity of spectrum is within manufacturer's recommendation	Call for maintenance service	Analyst or certified instrument technician	N/A
ICP/MS	Clean the torch in Aqua Regia solution and align the torch	Conduct leak test and adjust alignment	Inspect for leaks and align the torch and ensure that it is in the center	Each week (minimum every 2 weeks)	Torch is centered and no leaks	Replace or call for maintenance service	Analyst or certified instrument technician	N/A
ICP/MS	Clean the chamber and nebulizer	N/A	Visually inspect for foreign objects	Each week	Make sure chamber and nebulizer are clean	Replace or call for maintenance service	Analyst or certified instrument technician	N/A
GC/TCD/FID	Change septum, clean injection port, change or clip column, install new liner	Detector signals and chromatogram review	Instrument performance and sensitivity	As needed	CCV passes criteria	Re-inspect injector port, cut additional column, reanalyze CCV, recalibrate instrument	Analyst	N/A

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Auto-Titrator	No maintenance activity	N/A	N/A	N/A	N/A	N/A	Analyst	N/A
IC	Check the interior of the main compartment for leaks or spills, isolate and repair leaks. Check the waste container daily and empty when needed	Sensitivity check	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	Analyst	N/A
IC	Locate and replace any pinched or damaged lines. Check the junction between the pump head and the metal pump casting for evidence of liquid leaks. Normal friction and wear may gradually result in small liquid leaks around the piston seal. If leaks occur, replace the piston seals	Sensitivity check	Instrument performance and sensitivity	Daily or as needed	CCV pass criteria	Recalibrate	Analyst	N/A
TOC	No maintenance activity	N/A	N/A	N/A	N/A	N/A	Analyst	N/A

WORKSHEET #26: SAMPLE HANDLING SYSTEM

AECOM Sample Collection, Packaging, and Shipment	
Sample Collection (Personnel/Organization):	Field manager, field QC coordinator, field geologist / AECOM
Sample Packaging (Personnel/Organization):	Field manager, field QC coordinator, field geologist / AECOM
Coordination of Shipment (Personnel/Organization):	Field QC coordinator, field geologist / AECOM
Type of Shipment/Carrier:	Insulated cooler / FedEx Corporation
GCAL Sample Receipt and Analysis	
Sample Receipt (Personnel/Organization):	Sample Receipt Supervisor / GCAL
Sample Custody and Storage (Personnel/Organization):	Sample Receipt Supervisor /GCAL
Sample Preparation (Personnel/Organization):	Laboratory Manager / GCAL
Sample Determinative Analysis (Personnel/Organization):	Laboratory Manager / GCAL
GCAL Sample Archiving	
Field Sample Storage (No. of days from sample collection):	60
Sample Extract/Digestate Storage (No. of days from extraction/digestion):	60
Biological Sample Storage (No. of days from sample collection):	N/A
GCAL Sample Disposal	
Personnel/Organization:	Safety Officer / GCAL
Number of Days from Analysis:	60
Columbia Technology Sample Receipt and Analysis	
Sample Receipt (Personnel/Organization):	Chemist / Columbia Technologies
Sample Custody and Storage (Personnel/Organization):	Chemist / Columbia Technologies
Sample Preparation (Personnel/Organization):	Chemist/ Columbia Technologies
Sample Determinative Analysis (Personnel/Organization):	Chemist/ Columbia Technologies
Columbia Technology Sample Archiving	
Field Sample Storage (No. of days from sample collection):	Not applicable.
Sample Extract/Digestate Storage (No. of days from extraction/digestion):	Not applicable.
Biological Sample Storage (No. of days from sample collection):	Not applicable.
Columbia Technology Sample Disposal	
Personnel/Organization:	Chemist / Columbia Technologies
Number of Days from Analysis:	Not applicable.

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WORKSHEET #27: SAMPLE CUSTODY REQUIREMENTS

Sample custody requirements are followed to verify that samples were not tampered with and to ensure the quality and representativeness of samples and associated data. Sample custody requirements include following acceptable management practices which include field and laboratory custody procedures.

27.1 Field Custody Procedures

Field custody procedures are initiated after field samples have been collected. Field custody procedures include properly documenting the collection of investigation samples, appropriately naming samples, and properly managing and shipping samples.

27.1.1 Field Documentation

Field forms and other records will be populated to properly document sample collection. Entries in each document will be written legibly and in ink. These documents will be used to record information about each sample including the sample identification number, sample time and date, location, sample matrix, and analytical matrix.

27.1.2 Sample Identification Number

Each sample will be assigned a unique sample identification number. A sample identification number will be used to provide sample-specific information using a naming convention. The sample identification number will be used to identify the site, location, matrix, and depth of each sample.

The sample identification number for soil and groundwater samples collected via DPT will be assigned as follows:

OMS28-bbbb-c-d

Where:

bbbb = Sample location (i.e. SS01, SB01, GW01; Table 27-1)

c = bottom of sample depth interval

d = Field QC sample type (Table 27-2)

Table 27-1: Sample Location Identifiers

Identifier	Sample Type	Matrix
SS	Surface soil (0-1 bgs)	Soil
SB	Subsurface soil	Soil
GW	Groundwater Grab	Water
"Existing Well ID"	Groundwater	Water

Table 27-2: Field QC Sample Type Identifiers

Identifier	QC Sample Type	Description
a	Field Duplicate (Fixed and Mobile Lab)	Co-located for soil / replicate for water
c	Trip Blank (Fixed and Mobile Lab)	Water

Identifier	QC Sample Type	Description
s	Split Sample with Fixed Lab	Co-located for soil / replicate for water
ms/msd	Matrix Spike/Matrix Spike Duplicate (Fixed and Mobile Lab)	Co-located for soil / replicate for water

Examples of sample identification numbers are provided in Table 27-3.

Table 27-3: Examples of Sample Identification Numbers

Example	Sample Identification Number
Eighth surface soil sample collected via DPT from interval 0-1. Soil collected at bottom depth.	OMS28-SS08-1
Eleventh subsurface soil sample location collected via DPT from interval 2-4. Soil collected at bottom depth.	OMS28-SB11-4
Split subsurface soil sample collected via DPT co-located with soil sample 11 sample location from interval 2-4. Soil collected at bottom depth.	OMS28-SB11-4-s
Duplicate surface soil sample collected via DPT co-located with soil sample eighth sample location from interval 2-4. Soil collected at bottom depth.	OMS28-SS08-1-a
Groundwater sample collected from monitoring well OMS-28-5	OMS-28-5
Tenth groundwater sample collected via DPT from the depth of 20-24 feet.	OMS28-GW10-24
Duplicate sample on a split groundwater sample collected via DPT replicate with location 10 at a depth interval of 5-10 feet.	OMS28-GW10-5-s-a

27.1.3 Sample Management and Chain of Custody

Investigation samples will be appropriately managed from the time of collection through the time of relinquishment. A sample label that describes the sample will be affixed to each sample bottle/container. While under AECOM custody, samples will be maintained at a temperature of 4±2°C to meet preservation requirements, with the exception of samples to be analyzed by the mobile, on-site laboratory. These samples will be delivered to the mobile, on-site laboratory immediately upon collection for analysis.

CoC forms will be completed daily to manage samples and to track samples for shipment. CoC forms include the following information:

- Sample identification number
- Sample matrix
- Sample time
- Sample date
- Analytical methods
- Project number
- Site name
- Types of sample preservative
- Custody signatures and the date and time of receipt/relinquishment

27.1.4 Shipping

Samples will be packed in coolers and shipped to the fixed, off-site analytical laboratory. Samples will be packed with wet ice in each cooler. A temperature blank (a small polypropylene bottle or VOC vial filled with de-ionized water) will be placed in each cooler and will be used to determine the core temperature of the received samples by the laboratory technician. One copy of the CoCs will be placed in each cooler. The cooler will be sealed with strapping tape or equivalent, and CoC seals will be placed over the cooler lid and body interface or “Stop” tape will be used over the cooler lid. A bill of transport that includes shipping information shall be affixed to each cooler. Samples will be shipped within 2 days of collection using a secure carrier.

Samples that will be analyzed by the mobile, on-site laboratory will not require shipping.

27.2 Laboratory Sample Custody Procedures

Laboratory sample custody procedures will be initiated after the laboratory representative has signed for the sample cooler shipments (fixed, off-site laboratory) or sample containers (mobile, on-site laboratory). Laboratory sample custody procedures include properly documenting the receipt of samples, managing samples by properly storing, archiving, and analyzing samples, and disposing of excess sample mass/volume. Samples received at the fixed, off-site analytical laboratory will be managed in accordance with Section 5.8, “Handling Samples and Test Items” of the DoD QSM (DoD, 2013) and per laboratory SOPs.

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WORKSHEET #28: LABORATORY QC SAMPLES TABLE

Worksheet #28.1: Laboratory QC Samples Tables for Fixed, Off-Site Laboratory

Matrix	**Surface and Subsurface Soil**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: N/A Laboratory SOP: GCMSV-003
Analytical Organization	GCAL

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action by Lab	DQI	Project-Specific measured performance criteria (MPC)
Method Blank	1 per batch; maximum of 20 samples	No analytes detected > ½ Reporting Limit (RL). For common laboratory contaminants, no analytes detected > RL.	Correct problem; reanalyze any sample associated with a blank that fails criteria, except when the sample analysis resulted in a non-detect.	Analyst, Supervisor, QA Manager	Bias Contamination	Same as method
Laboratory Control Sample (LCS)	1 per batch; maximum of 20 samples	QC acceptance criteria specified in QSM 4.2 Table G-5 if available or laboratory limits.	Reanalyze and/or reprep all associated samples unless recoveries are high with no detection of analytes.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method
MS/MSD	One pair per batch or as specified by client request	For matrix evaluation, use LCS recovery and RPD acceptance criteria	Reanalyze if sufficient sample is available unless recoveries are high with no detection of analytes. If reprep and reanalysis confirms low recoveries, report and narrate.	Analyst, Supervisor, QA Manager	Accuracy Bias Precision	Same as method

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action by Lab	DQI	Project-Specific measured performance criteria (MPC)
Internal Standards	In all field samples, calibrations and QC standards	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; Extracted Ion Current Profile (EICP) area within -50% to +100% of ICAL midpoint standard	Inspect Mass spectrometer or GC for malfunctions. Reanalyze all samples with IS failures. If reanalysis confirms matrix interference, report sample and narrate.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method
Surrogates	In all field samples, calibrations and QC standards	QC acceptance criteria specified in QSM 4.2 Table G-3 if available or laboratory limits.	Evaluate the data to determine if the failed criteria are due to sample matrix or laboratory error. Re-prep if sufficient sample is available when appropriate.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method

Matrix	**Groundwater**
Analytical Group	**TCL VOCs**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: N/A Laboratory SOP: GCMSV-003
Analytical Organization	GCAL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Method Blank	One per preparatory batch	No analytes detected > ½ RL. For common laboratory contaminants, no analytes detected > RL.	Correct problem; reanalyze any sample associated with a blank that fails criteria, except when the sample analysis resulted in a non-detect.	Analyst, Supervisor, QA Manager	Bias Contamination	No analytes detected > ½ RL or > RL for common laboratory contaminants
Surrogates	All field and QC samples	Recoveries vary, in accordance with DOD QSM Version 4.2	Reanalyze and/or reprep if sufficient sample is available unless recoveries are high with no detection of analytes. If reprep and reanalysis confirms low recoveries, report and narrate.	Analyst, Supervisor, QA Manager	Accuracy Bias	Recoveries vary, in accordance with DOD QSM Version 4.2
LCS	One LCS per preparatory batch	Recoveries vary, in accordance with DOD QSM Version 4.2	Reanalyze and/or reprep all associated samples unless recoveries are high with no detection of analytes.	Analyst, Supervisor, QA Manager	Accuracy Bias	Recoveries vary, in accordance with DOD QSM Version 4.2
Internal Standards	In all field samples and standards	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; Extracted Ion Current Profile (EICP) area within -50% to +100% of ICAL midpoint standard	Inspect Mass spectrometer or GC for malfunctions. Reanalyze all samples with IS failures. If reanalysis confirms matrix interference, report sample and narrate.	Analyst, Supervisor, QA Manager	Accuracy Bias	Retention time ± 30 seconds; EICP area within -50% to +100% of midpoint of ICAL

Matrix	**Groundwater**
Analytical Group	**TCL VOCs**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: N/A Laboratory SOP: GCMSV-003
Analytical Organization	GCAL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD	One per preparatory batch per matrix	For matrix evaluation, use LCS recovery and RPD acceptance criteria specified in DOD QSM 4.2	Evaluate the data to determine if the failed criteria are due to sample matrix or laboratory error. Re-prep if sufficient sample is available when appropriate.	Analyst, Supervisor, QA Manager	Accuracy Bias Precision	Recoveries vary, in accordance with DOD QSM Version 4.2

Worksheet #28.2: Laboratory QC Samples Tables for Mobile, On-Site Laboratory

Matrix	**Surface and Subsurface Soil**
Analytical Group	**PCE and TCE**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: EPA 5035 Laboratory SOP: CT-ORG-001/CT-EXT-002
Analytical Organization	Columbia Technologies

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action by Lab	DQI	Project-Specific MPC
Method Blank	1 per batch; maximum of 20 samples	One per daily analysis batch.	No target analyte detected ≥½ RL (common laboratory contaminants, no analytes detected >RL) and >1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Analyst, Technical Director, QA Manager	Bias Contamination	Same as method
Laboratory Control Sample (LCS) – all target analytes spiked at ≤50% of linear range calibrated. Prepared same as ICV.	One per daily analysis batch.	Must be within control limits established by lab.	Correct the problem. Re-prep and reanalyze LCS. Reanalyze associated samples for failed analytes.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action by Lab	DQI	Project-Specific MPC
Matrix Spike/Matrix Spike Duplicate (MS/MSD) – all target analytes spiked at same conc. as LCS	One MS/MSD every 20 samples per matrix. MSD or sample duplicate RPD ≤ 30% (between MS and MSD or sample and sample duplicate)	Within control limits established by lab.	Check LCS to determine if matrix effects apply. Examine project specific data quality objectives. Contact client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy Bias Precision	Same as method
Internal standard verification	Every field sample, sample, and quality control sample.	Retention time must be < 30 seconds from retention time of the midpoint standard of most recent ICAL. The IS responses must be within –50% to +100% of those in the midpoint standard of the most recent ICAL.	Inspect mass spectrometer and GC malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action by Lab	DQI	Project-Specific MPC
Surrogates – 4-Bromofluorobenzene, 1,2-Dichloroethane-d4, Toluene-d8, 1,4-Dichlorobenzene.	All samples, spikes, standards, and method blanks.	Must be within control limits established by lab or the method.	For QC and field samples, correct problem then reprep and reanalyze all failed samples with failed surrogates in the associated batch. If one or more still remain outside criteria, recalibrate and or remake surrogate solution. If sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method

Matrix	**Groundwater**
Analytical Group	**PCE and TCE**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: EPA 5030 Laboratory SOP: CT-ORG-001/CT-EXT-001
Analytical Organization	Columbia Technologies

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action	DQI	Project-Specific MPC
Method Blank	1 per batch; maximum of 20 samples	One per daily analysis batch.	No target analyte detected >½ RL (common laboratory contaminants, no analytes detected >RL) and >1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Analyst, Technical Director, QA Manager	Bias Contamination	Same as method
Laboratory Control Sample (LCS) – all target analytes spiked at <50% of linear range calibrated. Prepared same as ICV.	One per daily analysis batch.	Must be within control limits established by lab.	Correct the problem. Re-prep and reanalyze LCS. Reanalyze associated samples for failed analytes.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method
Matrix Spike/Matrix Spike Duplicate (MS/MSD) – all target analytes spiked at same conc. as LCS	One MS/MSD every 20 samples per matrix. MSD or sample duplicate RPD < 30% (between MS and MSD or sample and sample duplicate)	Within control limits established by lab.	Check LCS to determine if matrix effects apply. Examine project specific data quality objectives. Contact client as to additional measures to be taken.	Analyst, Supervisor, QA Manager	Accuracy Bias Precision	Same as method

Matrix	**Groundwater**
Analytical Group	**PCE and TCE**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: EPA 5030 Laboratory SOP: CT-ORG-001/CT-EXT-001
Analytical Organization	Columbia Technologies

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action	DQI	Project-Specific MPC
Method Blank	1 per batch; maximum of 20 samples	One per daily analysis batch.	No target analyte detected >½ RL (common laboratory contaminants, no analytes detected >RL) and >1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Analyst, Technical Director, QA Manager	Bias Contamination	Same as method
Internal standard verification	Every field sample, sample, and quality control sample.	Retention time must be < 30 seconds from retention time of the midpoint standard of most recent ICAL. The IS responses must be within –50% to +100% of those in the midpoint standard of the most recent ICAL.	Inspect mass spectrometer and GC malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method

Matrix	**Groundwater**
Analytical Group	**PCE and TCE**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: EPA 5030 Laboratory SOP: CT-ORG-001/CT-EXT-001
Analytical Organization	Columbia Technologies

QC Sample	Number/ Frequency	Method/SOP Acceptance Criteria	Corrective Action	Title/Position of Person Responsible for Corrective Action	DQI	Project-Specific MPC
Method Blank	1 per batch; maximum of 20 samples	One per daily analysis batch.	No target analyte detected ≥½ RL (common laboratory contaminants, no analytes detected >RL) and >1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Analyst, Technical Director, QA Manager	Bias Contamination	Same as method
Surrogates – 4-Bromofluorobenzene, 1,2-Dichloroethane-d4, Toluene-d8, 1,4-Dichlorobenzene.	All samples, spikes, standards, and method blanks.	Must be within control limits established by lab or the method.	For QC and field samples, correct problem then reprep and reanalyze all failed samples with failed surrogates in the associated batch. If one or more still remain outside criteria, recalibrate and or remake surrogate solution. If sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst, Supervisor, QA Manager	Accuracy Bias	Same as method

Matrix	**Groundwater**
Analytical Group	**PCE and TCE**
Analytical Method/SOP Reference	Analytical Method: EPA 8260B Preparation Method: EPA 5030 Laboratory SOP: CT-ORG-001/CT-EXT-001
Analytical Organization	Columbia Technologies

QC Sample	**Number/ Frequency**	**Method/SOP Acceptance Criteria**	**Corrective Action**	**Title/Position of Person Responsible for Corrective Action**	**DQI**	**Project-Specific MPC**
Method Blank	1 per batch; maximum of 20 samples	One per daily analysis batch.	No target analyte detected >½ RL (common laboratory contaminants, no analytes detected >RL) and >1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Analyst, Technical Director, QA Manager	Bias Contamination	Same as method
Method Blank	1 per batch; maximum of 20 samples	One per daily analysis batch.	No target analyte detected >½ RL (common laboratory contaminants, no analytes detected >RL) and >1/10 the amount measured in any sample or 1/10 the regulatory limit (whichever is greater).	Analyst, Technical Director, QA Manager	Bias Contamination	Same as method

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WORKSHEET #29: PROJECT DOCUMENTS AND RECORDS TABLE

Document	Where Maintained
Sample Collection Documents and Records	
Daily Reports	AECOM Greenville Office
Groundwater Sampling Logs	AECOM Greenville Office
Soil Sampling Logs	AECOM Greenville Office
Chain-of-Custody Forms	AECOM Greenville Office, GCAL, Columbia Technologies
Off-site Analysis Documents and Records	
Air Bills	AECOM Greenville Office
Laboratory Data Reports	AECOM Greenville Office, GCAL, Columbia Technologies
Laboratory EDD	AECOM Greenville Office, GCAL, Columbia Technologies
Laboratory Instrument Calibration Logs	AECOM Greenville Office, GCAL, Columbia Technologies
Laboratory Sample Preparation Logs	AECOM Greenville Office, GCAL, Columbia Technologies
Laboratory Run Logs	AECOM Greenville Office, GCAL, Columbia Technologies
Laboratory Sample Disposal Records	GCAL and Columbia Technologies
Data Assessment Documents and Records	
Laboratory System Audit Report	AECOM Greenville Office
Laboratory Performance Audit Reports	AECOM Greenville Office
Daily Quality Control Report	AECOM Greenville Office
Field System Audit Reports	AECOM Greenville Office
Field Performance Audit Reports	AECOM Greenville Office
Third-Party data Validation Reports (Review and Performance)	AECOM Denver Office
Assessment Findings and Corrective Action Responses	AECOM Greenville Office
Work Plan	AECOM Greenville Office
Reports	AECOM Greenville Office
Other Documents and Records	
Well Development Logs	AECOM Greenville Office
Equipment Calibration Logs	AECOM Greenville Office
Waste Manifests	AECOM Greenville Office
Well Maintenance Logs and Photographs	AECOM Greenville Office
Personnel Qualifications	AECOM Offices Greenville
Survey Locations Data	AECOM Greenville Office
Health and Safety Sign-in Sheets	AECOM Greenville Office
Health and Safety Plan Acknowledgement	AECOM Greenville Office

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WORKSHEET #30: ANALYTICAL SERVICES TABLE

Worksheet #30.1: Analytical Services Table for Fixed, Off-Site Laboratory

Samples collected as split samples (including split duplicates and split ms/msd samples) will be shipped to GCAL:

Gulf Coast Analytical Laboratories, Inc.
7979 GSRI Avenue
Baton Rouge, LA 70820
Phone: 225-769-4900
Fax: 225-7675717

Project Manager: Kimberly Drag
E-mail: kimberly.drag@gcal.com
Direct: 704-607-7735

Preliminary analytical data packages will be provided to AECOM within 14 days after sample coolers are received by the laboratory. Complete data report packages will be submitted electronically as a PDF to AECOM 21 days. Final analytical data packages will be provided to AECOM within 28 days of sample receipt.

Data report packages will include the following sections:

- Signed cover sheet;
- Signed CoC;
- Sample condition-upon-receipt form;
- Case narrative;
- Analytical results; and
- QA/QC information (including all method blanks, surrogate recoveries, laboratory control sample/ laboratory control sample duplicate recoveries, and MS/MSD recoveries)

Worksheet #30.2: Analytical Services Table for Mobile, On-Site Laboratory

All samples collected as primary samples will be hand delivered to the Columbia Technologies mobile, on-site laboratory at the designated on-site location.

Columbia Technologies
Project Manager: To Be Determined
E-mail: To Be Determined
Direct: To Be Determined

Preliminary analytical data packages will be provided to AECOM within 24-hours after the sample is received by the laboratory. Complete data report packages will be submitted electronically to AECOM within 21 days. Final data packages will be provided to AECOM within 28 days of sample receipt.

Data report packages will include the following sections:

- Signed cover sheet;
- Signed CoC;
- Sample condition-upon-receipt form;
- Case narrative;
- Analytical results; and
- QA/QC information (including all method blanks, surrogate recoveries, laboratory control sample/laboratory control sample duplicate recoveries, and MS/MSD recoveries).

WORKSHEET #31: PLANNED PROJECT ASSESSMENTS TABLE

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Action	Person(s) Responsible for Monitoring Effectiveness of Corrective Action
Review of field procedures	Daily	Internal	AECOM	Field Manager	Technical Lead	Field Manager	Project Manager
Review of field notes	Weekly	Internal	AECOM	Field Manager / Field QC Coordinator	Technical Lead	Field Manager	Project Manager
Review of field instrument calibration sheets	Daily	Internal	AECOM	Field Manager	Technical Lead	Field Manager	Project Manager
Review of CoC forms	Daily	Internal	AECOM	Project Chemist	Technical Lead	Technical Lead	Project Manager
Review of Technical Documents	Once per report	Internal	AECOM	AECOM QA Program Manager, Risk Assessor, Alabama PG, and Project Manager	Technical Lead	Technical Lead	Project Manager
Laboratory data assessment	Once per sample delivery group (SDG)	External / Internal	AECOM	Data Validator / Project Chemist	Technical Lead	Technical Lead	Project Manager

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WORKSHEET #32: ASSESSMENT FINDINGS AND CORRECTIVE ACTION RESPONSES

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response[a]	Timeframe for Response
Review of field procedures	Verbal communication/ Daily Reports	Technical Lead	24 hours after audit	Letter or e-mail	PM	24 hours after notification
Review of field notes	Daily Reports	Technical Lead	24 hours after audit	Daily Reports	PM	24 hours after notification
Review of field instrument calibration sheets	Calibration Logs	Technical Lead	24 hours after audit	Calibration Logs	Field Manager	24 hours after notification
Review of CoC forms	CoC forms	Field Manager	24 hours after audit	Letter or e-mail	QC Coordinator / Field Manager, AECOM	24 hours after notification
Review of Technical Documents	AECOM Document Review and Verification Form and Delivery Release Record	Technical Lead	2 weeks	AECOM Document Review and Verification Form and Delivery Release Record	PM	24 hours after notification
Laboratory data assessment	Verbal communication or e-mail	Technical Lead	24 hours after audit	Letter or e-mail	Project Chemist	24 hours after notification

[a] Copies of all assessment findings and corrective action responses will be provided to the USACE Mobile District project manager.

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WORKSHEET #33: QUALITY ASSURANCE MANAGEMENT REPORTS TABLE

This worksheet identifies the planned Quality Assurance Management Reports used to ensure that managers and stakeholders are updated on project status and results of planned project assessments. These quality assurance reports are designed to address deviations from the approved UFP-QAPP; results of data review activities in terms of amount of usable data generated; limitations on the use of measurement data generated; and data usability assessments in terms of precision, accuracy, representativeness, completeness, comparability, and sensitivity.

Type of Report	Frequency	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Daily Quality Control Report	Daily during field work	Submitted at the end of each field work week	Field Manager	AECOM PM
Combined Laboratory System and Performance Audit Report	As required	30 days after completion of the audit	Project Chemist	USACE PM and AECOM QA Program Manager
Data Assessment Report	Once for each SDG	21 days after receipt of data	Project Chemist	USACE PM and AECOM QA Program Manager

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WORKSHEET #34: DATA VERIFICATION INPUTS (STEP I)

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/ External
Laboratory system audits	Determine whether the laboratory holds a current DoD ELAP certification (fixed, off-site laboratory only) for all analyses to be performed for the project.	Project Chemist	Internal
Field procedures	Determine whether field procedures are performed in accordance with this WP and prescribed procedures.	Technical Lead	Internal
Field forms and notes	Review the field forms and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the CTO manager and included in the Field Audit Report.	Field Manager and Technical Lead	Internal
Instrument calibration sheets	Determine whether instruments are calibrated and used in accordance with manufactures' requirements.	Field Manager	Internal
CoC forms	Review CoC completed forms and verify them against the corresponding packed sample coolers. A copy of each CoC will be placed in the project file. The original CoC will be taped inside the cooler for shipment to the analytical laboratory.	Field Manager and Project Chemist	Internal
Sampling analytical data package	Verify all analytical data packages for completeness prior to submittal of the data to the data validator.	Lab Project Manager	External

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WORKSHEET #35: DATA VALIDATION PROCEDURE (STEPS IIA/IIB) TABLE

Data Review Input	Description	Responsible for Verification (name, organization)	Step IIa / IIb [a]	Internal/ External
Analytes	Determine whether all analytes specified in Worksheet #15 were analyzed and reported on by the laboratory.	Project Chemist	Step IIa	Internal
CoC and field QC notes	Examine data traceability from sample collection to project data generation.	Project Chemist	Step IIa	Internal
Laboratory data and WP requirements	Assess and document the performance of the analytical process. A summary of all QC samples and results will be verified for measurement performance criteria and completeness. Standard Validation will be performed on 100% of the data. A report will be prepared within 21 days of receipt.	Project Chemist	Steps IIa & IIb	Internal

[a] IIa compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP manual, V.1 (DoD 2005).
IIb comparison with measurement performance criteria in the WP. See Table 11, page 118, UFP-QAPP manual, V.1 (DoD 2005).

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WORKSHEET #36: DATA VALIDATION PROCEDURES (STEPS IIA/IIB) TABLE

Data Review Input	Description	Responsible for Verification (name, organization)	Step I / IIa / IIb [a]	Internal/ External
VOCs	Complete Procedure II-B Standard and Standard Data Validation Procedure for GC/MS Volatile Organics by SW-846 8260B.	Project Chemist	Step IIa	Internal
Sampling plan	Determine whether the number and type of samples specified in Worksheet #20 were collected and analyzed.	Project Chemist & Technical Lead	Step IIb	Internal
Field QC samples	Establish that the number of QC samples specified in Worksheet #20 were collected and analyzed.	Project Chemist	Step IIb	Internal
Project quantitation limits and data qualifiers	Establish that sample results met the project quantitation limits and qualify the data in accordance with Procedure II-A, *Data Validation Procedure.*	Project Chemist	Step IIb	Internal
Validation report	Summarize outcome of data comparison to MPC in the WP. Include qualified data and an explanation of all data qualifiers.	Project Chemist	Step IIa	Internal

[a] IIa compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP manual, V.1 (DoD 2005).
IIb comparison with measurement performance criteria in the WP. See Table 11, page 118, UFP-QAPP manual, V.1 (DoD 2005).

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WORKSHEET #37: USABILITY ASSESSMENT

This worksheet provides procedures, methods, and activities to determine whether data are of the right type, quality, and quantity to support environmental decision-making for the project.

37.1 Summary Of The Usability Assessment Process And Procedures

A usability assessment to determine how well the data collected on this project support the project objectives and decisions to be made will be performed by a project team from AECOM.

During the field effort, a field audit will be performed to assess sample collection procedures. The field audit will verify that proper procedures (as outline in Worksheet #17) are followed, and soil and groundwater data (screening-level and definitive-level) are being generated on an acceptable level. Definitive-level analytical data will be sent to AECOM for data validation. AECOM will determine the usability of the analytical data and will identify any limitations on the use of the data. All raw data and electronic copies of screening-level data will be retained by AECOM in the event data reconstruction/validation is deemed necessary.

The usability of data collected during this Supplemental Data Gap Investigation will be assessed several ways. First, any deviations from proposed field activities and sampling and handling procedures will be reviewed, and their effect on data usability evaluated as presented on Worksheets #12 and #28. Second, the analytical results of the sampling will be compared to the DQOs presented on Worksheets #11 to determine whether the MPC were met. Upon completion of the verification and validation processes noted on Worksheet #34 and Worksheet #35, the DQIs will be evaluated for each analytical group. Based on the results of this examination, conclusions regarding the validity and usability of data for each analytical group will be drawn. A Data Quality Assessment Report will be prepared by the Data Validator and provided to the PM within 21 days of receipt from the laboratory. Overall measurement error (sampling plus analytical) will be assessed as noted below. The Supplemental Data Gap Report and 2015 Annual Groundwater Monitoring Report will include discussions of conclusions drawn and any limitations on the use of project data as a result of this assessment.

37.2 Evaluation Procedures Used To Assess Overall Measurement

37.2.1 Error Associated with the Project

Measurement error will be evaluated by reviewing sampling design, sampling locations, and sample collection methods. AECOM will evaluate QC samples (see Worksheet #20) to assess the overall measurement error associated with the project.

37.2.2 Personnel Responsible for Performing the Usability Assessment

AECOM will generate validated data packages to be presented in the Supplemental Data Gap Report and 2015 Annual Groundwater Monitoring Report. The usability assessment will generate a letter report describing the means and methods of the usability assessment and the results. All data sets will be evaluated using PARCC criteria developed during the site-specific DQO development process and summarized below.

- The AECOM project chemist will be responsible for performing the analytical data usability assessment.

- The AECOM project chemist will also perform a usability assessment of the validated data and screening-level data. This usability assessment will include:
    - (1) review of accepted or rejected data,
    - (2) review of data qualifiers,
    - (3) review of laboratory surrogate recoveries,
    - (4) review of laboratory control samples, and
    - (5) consultation with the analytical laboratory
- The AECOM Technical Lead, will use the results of both usability assessments to determine whether the data generated during the investigation can be used to answer the principle study questions

37.2.3 Documentation to be Generated During Usability Assessment and How Results will be Presented

Precision and Accuracy: Precision and accuracy are evaluated using DQIs, such as MS/MSDs, laboratory control samples, and surrogates. Precision and accuracy of the data set are considered acceptable after integration of qualification of estimated (i.e., estimated [J] and non-detected estimated [U]) results.

Representativeness: All samples for each method and matrix are evaluated for holding time compliance. All samples are associated with a method blank in each individual SDG. Representativeness of the project data is considered acceptable after qualification for blank contamination.

Comparability: In general, data comparability is evaluated through the collection and analysis of field duplicates and field blanks. The laboratory will use standard analytical methods for their analyses. The analytical results will be reported in correct standard units. Holding times, sample preservation, and sample integrity will be within QC criteria. For the purpose of this investigation, comparability between samples run on both field screening instruments (intra-laboratory precision) and comparability of field screening-data with fixed base definitive-data (inter-laboratory accuracy and precision) will also be performed to enhance the comparability assessment.

Completeness: The overall completeness will be determined by the total number of analytes reported versus the number of sample results rejected in percent. The completeness percentage based on rejected data should meet the 90% goal.

Uncertainty Discussion of Reporting Limits: The magnitude of the laboratory reporting limits might have an effect on the results of any environmental investigation. For instance, if a chemical is present in an environmental medium at concentrations below the highest reporting limit and below the screening criteria, then that chemical should be eliminated from consideration as COPC. However, it is also possible that a chemical is present below the reporting limit and above the screening criteria; therefore, the assumption that the chemical is not present would potentially result in an underestimation of the potential impact of contamination. As a result, the chemical should not be eliminated from the COPC list and may require further evaluation. Project-specific items that will be considered when part of the data usability assessment are provided below.

Item	Assessment Activity	Responsibility
Data Deliverables and Work Plan	Ensure that all necessary information was provided, including but not limited to, QC sample results and data validation results.	Project Chemist
Sampling Locations, Deviation	Determine whether alterations to sampling locations continue to satisfy the project quality objectives.	Field Manager
Chain-of-Custody, Deviation	Establish that any problems with documentation or custody procedures do not prevent the data from being used for the intended purpose.	Project Chemist
Holding Times, Deviation	Determine the acceptability of data where holding times were exceeded.	Project Chemist
SOPs and Methods, Deviations	Evaluate the impact of deviations from analytical and field SOPs and specified methods on data quality.	Field Manager Project Chemist
QC Samples	Evaluate the implications of unacceptable QC sample results on the data usability for the associated samples. For example, consider the effects of observed blank contamination.	Project Chemist
Matrix	Evaluate matrix effects (interference or bias).	Project Chemist
Meteorological Data and Site Conditions	Evaluate the possible effects of meteorological (e.g., wind, rain, temperature) and site conditions on sample results. Review field reports to identify whether any unusual conditions were present and how the sampling plan was executed.	Field Manager
Precision	Evaluate analytical precision measurements. Precision measures the reproducibility of a measurement and is defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions.	Project Chemist
Accuracy	Evaluation of how close the analytical result is to the true value of the analyte in a sample. Accuracy is a statistical measurement of correctness. It includes components of random error (variability due to imprecision) and systemic error. It reflects the total error associated with a measurement.	Project Chemist
Comparability	Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved by using standard techniques to collect and analyze representative samples and reporting analytical results in appropriate units	Project Chemist
Representativeness	Determine the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representativeness is achieved through use of the standard sampling, field, and analytical procedures.	Project Chemist

Item	Assessment Activity	Responsibility
Completeness	Evaluate the impact of missing information. Ensure that enough information was obtained for the data to be usable (completeness as defined in DQOs documented in this Work Plan).	Project Chemist
Critical Samples	Establish that critical samples and critical target analytes, as defined in the Work Plan, were collected and analyzed. Determine whether the results meet criteria specified in the Work Plan.	Project Chemist
Data Restrictions	Describe the exact process for handling data that do not meet DQOs (i.e., when measurement performance criteria are not met). Depending on how those data will be used, specify the restrictions on use of those data for environmental decision-making.	Project Chemist
Usability Decision	Determine whether the data can be used to make a specific decision considering the implications of all deviations and corrective actions.	Project Chemist
Usability Report	Discuss and compare overall precision, accuracy/bias, representativeness, comparability, completeness, and sensitivity for each matrix, analytical group, and concentration level. Describe limitations on the use of project data if criteria for DQIs are not met.	Project Chemist

References

40 Code of Federal Regulations (CFR) 261.24. 2010. Identification and Listing of Hazardous Waste. Subpart C: Characteristics of Hazardous Waste, 1 July.

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ADEM, 2008. Alabama Risk-Based Corrective Action (ARBCA) Guidance Manual, Revision 2, April 2008.

ADEM, 2010a. E-mail from Colin Mitchell (Environmental Engineering Specialist, ADEM Hazardous Waste Branch) to Glenn Elliott (National Guard Bureau, CC Program Manager), notice to proceed with CERCLA track at OMS-28, September 9.

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Aerostar, 2007. TCE Comprehensive Investigation at the Organizational Maintenance Shop 28 (OMS-28),Alabama Army National Guard, 1622 South Broad Street, Mobile, Alabama, Groundwater Incident No. GW 07-01-02, April 2007.

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FIGURES

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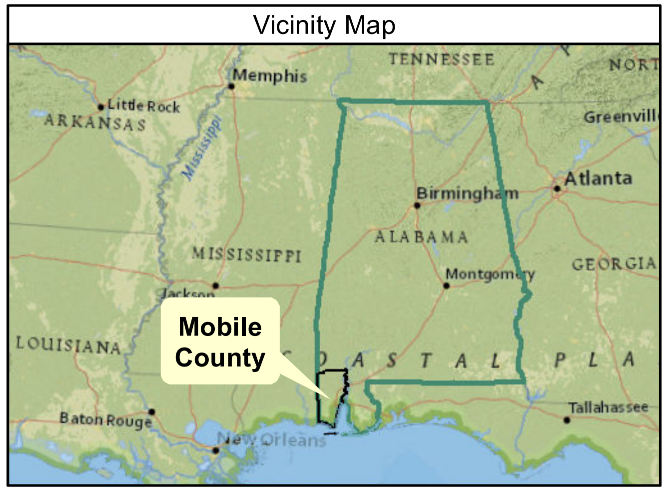
Vicinity Map



Legend

▭ County

▨ Waterbodies

0 300 600 1,200 Feet

1 inch = 600 feet

N E S W

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Facility Location Map

Alabama Army National Guard OMS #28

Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/11/2015	**Figure 1**

Document Path: L:\Projects\60439687 Brookley\900-CADD-GIS\Brookley_GIS\Maps\VK\2015_09_23\Figure 1_Brookley_Location Map.mxd

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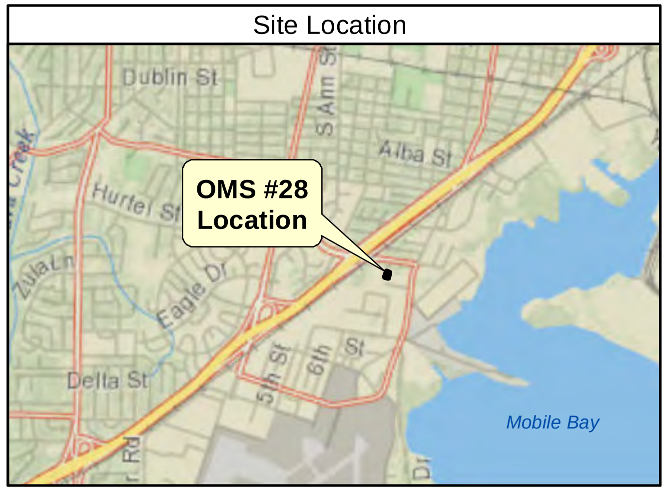
Facility Site Location Map

Alabama Army National Guard OMS #28
Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/7/2015	**Figure 2**

Document Path: L:\Projects\60439687 Brookley\900-CADD-GIS\Brookley_GIS\Maps\VK\2015_09_23\Figure 2_Brookley_Site_Location Map.mxd

Site Location



Legend

- 🔶 Shallow Monitoring Well
- 🟣 Deep Monitoring Well
- ← Apparent Groundwater Flow Direction (September 2010, Remedial Investigation, SAIC, May 2013)
- — PCE Isopleth (in µg/L; September 2010, Remedial Investigation, SAIC, May 2013)
- — TCE Isopleth (in µg/L, Dashed Where Inferred; September 2010, Remedial Investigation, SAIC, May 2013)
- —+— Railroad
- ----- Approximate Ditch Orientation
- → Approximate Ditch Orientation Flow
- × — Fenceline
- ☐ Parcel Boundary

0 60 120 240 Feet

1 inch = 120 feet

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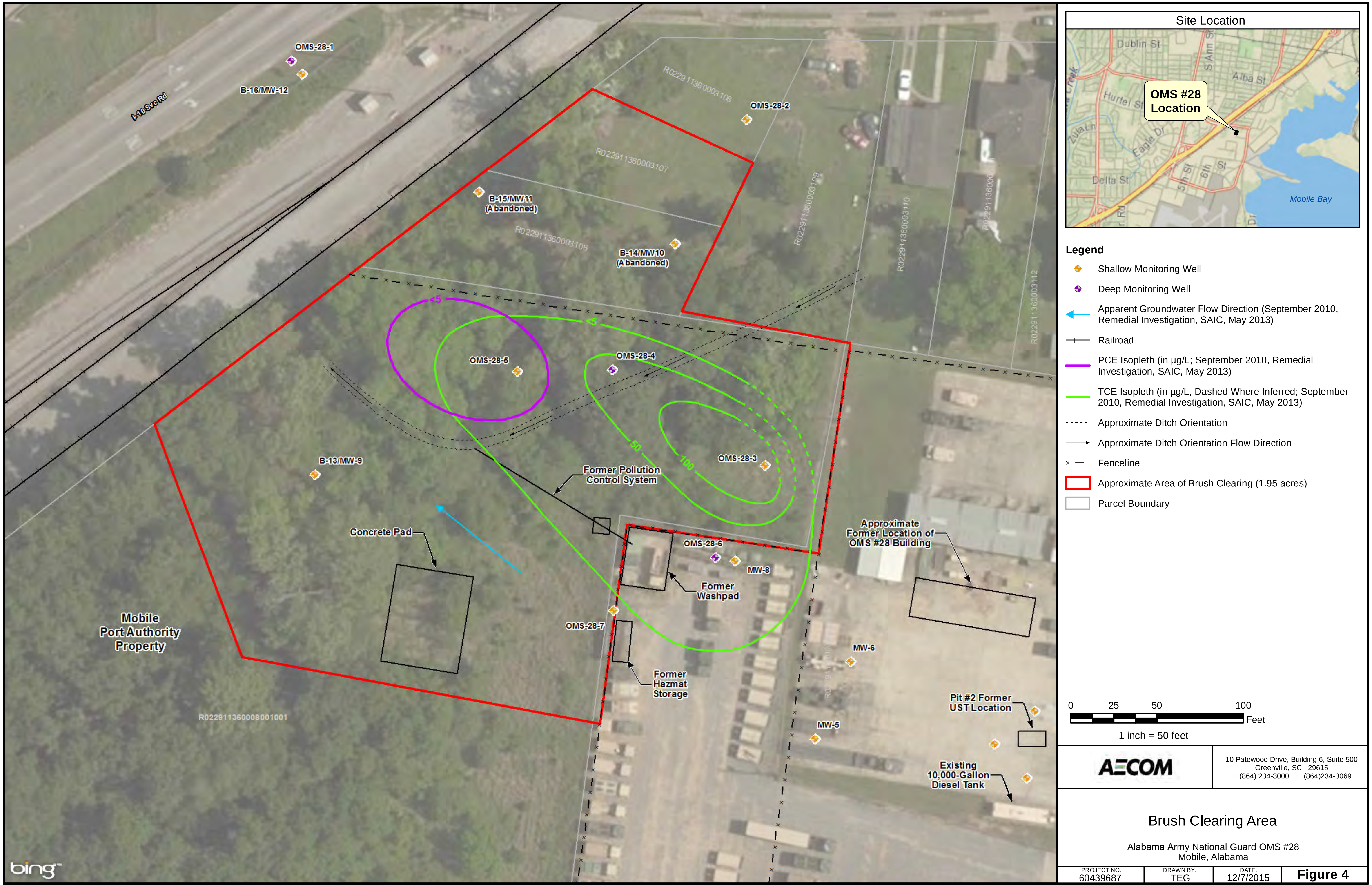
PCE/TCE Groundwater Plume 2010

Alabama Army National Guard OMS #28
Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/7/2015	**Figure 3**

Document Path: L:\Projects\60439687 Brookley\900-CADD-GIS\Brookley_GIS\Maps\VK\2015_09_23\Figure 3_Brookley_PCE TCE GW Plume 2010.mxd



Legend

- ◆ Shallow Monitoring Well
- ◆ Deep Monitoring Well
- ← Apparent Groundwater Flow Direction (September 2010, Remedial Investigation, SAIC, May 2013)
- Railroad
- PCE Isopleth (in µg/L; September 2010, Remedial Investigation, SAIC, May 2013)
- TCE Isopleth (in µg/L, Dashed Where Inferred; September 2010, Remedial Investigation, SAIC, May 2013)
- Approximate Ditch Orientation
- Approximate Ditch Orientation Flow Direction
- × — Fenceline
- 🟥 Approximate Area of Brush Clearing (1.95 acres)
- ☐ Parcel Boundary

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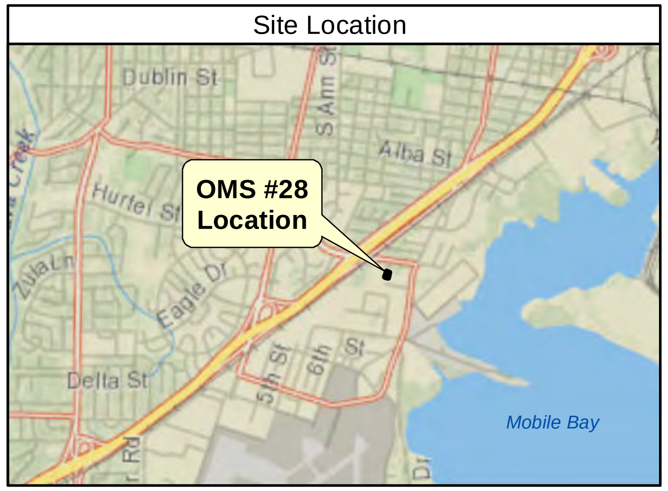
Brush Clearing Area

Alabama Army National Guard OMS #28
Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/7/2015	**Figure 4**

Document Path: L:\Projects\60439687 Brookley\900-CADD-GIS\Brookley_GIS\Maps\VK\2015_09_23\Figure 4_Brookley_Brush Clearing Area.mxd

Site Location



Legend

- ◆ Shallow Monitoring Well
- ◆ Deep Monitoring Well
- ─┼─ Railroad
- - - - - Approximate Ditch Orientation
- ──→ Approximate Ditch Orientation Flow Direction
- × ─ Fenceline
- ☐ Parcel Boundary

0 25 50 100 Feet

1 inch = 50 feet

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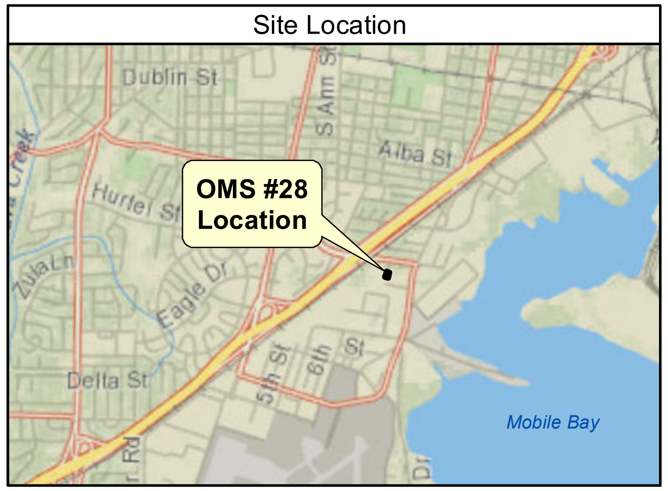
Monitoring Well Network

Alabama Army National Guard OMS #28
Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/7/2015	**Figure 5**

Site Location



Legend

- ■ Proposed Initial LLMIP Location
- ▲ Proposed HTP Location
- ◆ Shallow Monitoring Well
- ◆ Deep Monitoring Well
- ← Apparent Groundwater Flow Direction (September 2010, Remedial Investigation, SAIC, May 2013)
- —+— Railroad
- — TCE Isopleth (in μg/L, Dashed Where Inferred; September 2010, Remedial Investigation, SAIC, May 2013)
- — Soil Area Exceeding Groundwater SSL (Remedial Investigation, SAIC, May 2013)
- — PCE Isopleth (in μg/L; September 2010, Remedial Investigation, SAIC, May 2013)
- ----- Approximate Ditch Orientation
- ——→ Approximate Ditch Orientation Flow Direction
- × — Fenceline
- ☐ Approximate Area of Brush Clearing (1.95 acres)
- ☐ Parcel Boundary

Notes:
LLMIP - Low Level Membrane Interface Probe
HPT - Hydraulic Profiling Tool

LLMIP locations are initial starting location. Additional stepouts will be performed until the LLMIP does not indicate a response.

0 25 50 100 Feet
1 inch = 50 feet

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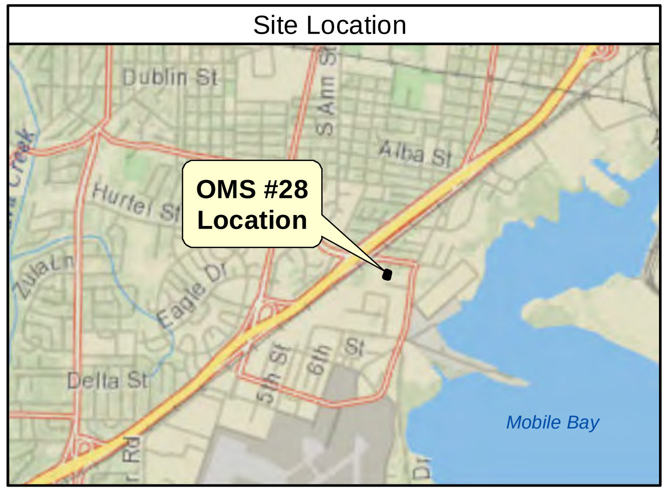
Proposed MIP / HTP Locations

Alabama Army National Guard OMS #28
Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/11/2015	**Figure 6**

Document Path: L:\Projects\60439687 Brookley\900-CADD-GIS\Brookley_GIS\Maps\VK\2015_09_23\Figure 6_Brookley_Proposed MIP HTP Locations.mxd

Site Location



Legend

●	Proposed Initial Soil Sample Location
◆	Shallow Monitoring Well
◆	Deep Monitoring Well
—+—	Railroad
←	Apparent Groundwater Flow Direction (September 2010, Remedial Investigation, SAIC, May 2013)
—	TCE Isopleth (in µg/L, Dashed Where Inferred; September 2010, Remedial Investigation, SAIC, May 2013)
-----	Approximate Ditch Orientation
→	Approximate Ditch Orientation Flow Direction
—	Soil Area Exceeding Groundwater SSL (Remedial Investigation, SAIC, May 2013)
—	PCE Isopleth (in µg/L; September 2010, Remedial Investigation, SAIC, May 2013)
× —	Fenceline
🟥	Approximate Area of Brush Clearing (1.95 acres)
☐	Parcel Boundary

Notes:

SB - Soil Boring Locations. Each soil boring location will have a surface soil (SS) sample and two subsurface soil (SO) samples.

Soil Sample Locations are initial starting locations. Samples to be analyzed by the onsite mobile lab and stepouts taken until the boundary is identified.

0 25 50 100
Feet

1 inch = 50 feet

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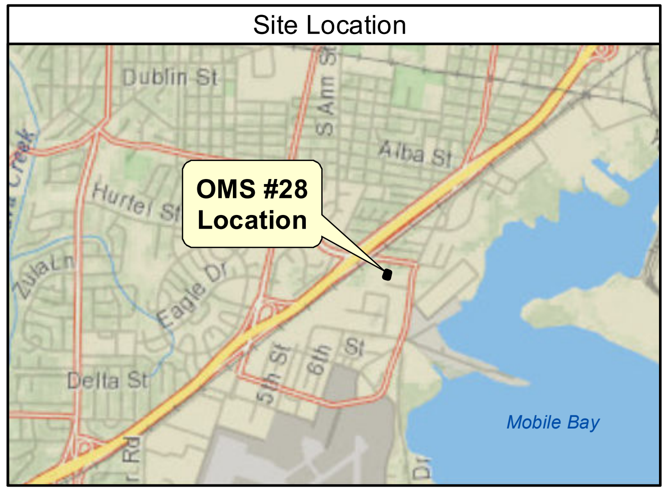
Proposed Soil Sample Locations

Alabama Army National Guard OMS #28
Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/7/2015	**Figure 7**

Document Path: L:\Projects\60439687 Brookley\900-CADD-GIS\Brookley_GIS\Maps\VK\2015_09_23\Figure 7_Brookley_Proposed Soil Sample Locations.mxd

Site Location



Legend

- ● Proposed Initial DPT Groundwater Grab Sample Location
- ● Proposed Secondary DPT Groundwater Grab Sample Location
- ● Proposed Tertiary DPT Groundwater Grab Sample Location
- ◆ Shallow Monitoring Well
- ◆ Deep Monitoring Well
- ← Apparent Groundwater Flow Direction (September 2010, Remedial Investigation, SAIC, May 2013)
- ┼ Railroad
- — TCE Isopleth (in µg/L, Dashed Where Inferred; September 2010, Remedial Investigation, SAIC, May 2013)
- — Soil Area Exceeding Groundwater SSL (Remedial Investigation, SAIC, May 2013)
- — PCE Isopleth (in µg/L; September 2010, Remedial Investigation, SAIC, May 2013)
- ----- Approximate Ditch Orientation
- → Approximate Ditch Orientation Flow Direction
- × — Fenceline
- 🟥 Approximate Area of Brush Clearing (1.95
- ☐ Parcel Boundary

Note:
Initial DPT groundwater location will be performed and analyzed first. The secondary DPT groundwater sample locations are stepouts from the initial location and will be collected, if necessary, on a selective basis pending the results of the initial locations. The tertiary sample locations are stepout location from the secondary locations, and will be collected, if necessary, on a selective basis, pending the results of the secondary sample. All samples will be analyzed by the onsite lab.

0 25 50 100 Feet

1 inch = 50 feet

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Proposed DPT Groundwater Sample Locations

Alabama Army National Guard OMS #28
Mobile, Alabama

PROJECT NO.	DRAWN BY:	DATE:	
60439687	TEG	12/11/2015	**Figure 8**

Document Path: L:\Projects\60439687 Brookley\900-CADD-GIS\Brookley_GIS\Maps\VK\2015_09_23\Figure 8_Brookley_DPT Groundwater Sample Locations.mxd

APPENDIX A

Field Sampling Forms

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DAILY QUALITY CONTROL REPORT

PAGE ____ OF ____

JOB NUMBER ______________ DATE ______________ REPORT NUMBER ______________

PROJECT & LOCATION ______________

WEATHER ______________ TEMPERATURE RANGE ______________ WIND ______________

AECOM PERSONNEL ON SITE ______________ TIME ON SITE ______________

SUMMARY OF SITE ACTIVITIES ______________

LEVEL OF HEALTH & SAFETY PROTECTION ______________

INSTRUMENTATION USED ______________

CALIBRATION(S) PERFORMED ______________

INSTRUMENT PROBLEMS / REMEDIES ______________

SAMPLES COLLECTED* ______________

SAMPLE COLLECTION METHOD(S) ______________

QUALITY CONTROL SAMPLES* ______________

ADDITIONAL REMARKS ______________

SIGNATURE: ______________

* INDICATE SAMPLE MEDIA: GROUND WATER, SURFACE WATER, SOIL OR SEDIMENT; SAMPLE TYPE:

AECOM

DAILY REPORT

JOB NUMBER: ______ **DATE:** ______ **REPORT NUMBER:** ______

PROJECT & LOCATION: ______

CLIENT: ______ **ET FIELD REPRESENTATIVE:** ______

SUBCONTRACTOR: ______

SUBCONTRACTOR PERSONNEL ON SITE: ______

BRIEF SUMMARY OF WORK PERFORMED: ______

______

START TIME	STOP TIME	DESCRIPTION OF ACTIVITIES; REMARKS	TIME SPENT

*** TIME SPENT BY SUBCONTRACTOR ON HOURLY RATE PAY ITEMS.**

FIELD REPRESENTATIVES' SIGNATURE: ______ **DATE:** ______

PAGE ______ OF ______

AECOM

WATER LEVEL DATA SUMMARY

PROJECT: ____________________

LOCATION ____________________

CLIENT ____________________

SURVEY DATUM: ____________________

MEASURING DEVICE: ____________________

JOB NUMBER ____________________

DATE ____________________

MEASURED BY ____________________

WELL NUMBER	TIME (Military)	MEASURING POINT		DEPTH TO WATER (FT)	ELEVATION OF WATER (FT)	COMMENTS
		Description	Elevation (FT)			

AECOM

Well Maintenance Form Instructions

Please write legibly and complete for each well visited.

General

Well ID – self explanatory

Well Identification – Specify how the well is identified (example: metal tag in concrete, paint on concrete or stick up vault, well plug marked, other, described) or note that Well ID missing or visible, etc.)

Well Pad – describe briefly the pad (example: 3'X3' concrete in grass, 2' diameter in asphalt, non, 4' square with 4 bollards approximately 3' in height, etc.) and it's condition (example: good, small cracks, deep cracks with displacement, undermined, pad rocks, vault is detached from concrete, etc.). If condition description requires more space continue in the "comments" section.

Vault

Vault Type – self explanatory

Vault Description – general description such as round, oval, square, metal, plastic, PVC, hinged lid, unusual locking mechanism or requires special key, (example: 8-inch square metal stick up with hinged lid; round metal with manhole; metal oval with unique lock-requires special key).

Vault Brand – name on vault, specifically manholes, the stick-ups may be "unknown" (example: Morris Industries, Universal, Boart Longyear).

Vault Size – diameter or dimension (if square)

Bolts – self explanatory

Bolt Size – sockets size, check one

Bolt Tab Condition – are they broken off or stripped?

Condition of Gasket – check condition, is it dry rotted, does it fit properly?

Condition of Vault Interior – is it full of water or something else, has the casing sunk or vault floor been filled in to top of casing, make note if there is water in vault, is it above at or below top of casing, this may indicate well plug leakage.

Well

Size – size of the well casing

Well Casing – what is the casing composed of?

Condition of the Top of Well Casing – is it cracked or uneven? Has it sunk below the vault floor?

Measure Point – check for the measuring point, a small notch cut into the top of the well casing or marked with permanent marker on outside of casing.

Well Plug Vented – self explanatory – you may need to clean the well plug to find the vent hole.

Well Plug Type – Self explanatory

Well Plug Condition – Self explanatory

Lock Present – Self explanatory

Lock Condition – does it work? Can you open it – if not, please mark comments with "LOCK NEEDS REPLACEMENT".

Does this well require a low profile schedule 80 or other special plug? Describe – self explanatory.

Other

Have you observed any plant or animal pests such as scorpions, bees, wasps, poison ivy, fire ants near the well?

Comments

Please add any other observations you note that may be important or detail for any of the above entries (example: well under water after rainstorm, well buried, plug under pressure, well in secure area that is locked at 4 pm, etc.)

AECOM

Well Maintenance Form

Date: ______________________

Recorded By: ________________

Well ID: ________________________ Well Identification: ____

Well Pad: ____

Vault Type: ☐ Flush Mount ☐ Stick Up Description: ____________________________________

Brand: __________________ Size: ☐ 8-inch ☐ 12-inch ☐ Other: _____

Bolts: ☐ Two ☐ Three ☐ Four ☐ N/A Bolt Size: ☐ 9/16 ☐ 5/8 ☐ 1/2 ☐ 3/4 ☐Other: _____

Bolt Tab Condition: _________________________________ Gasket: ☐ Good ☐ Poor/Usable ☐ Missing

Condition of Vault Interior: ____

Well Size: ☐ 2-inch ☐ 4-inch ☐Other: _________ Well Casing: ☐ PVC ☐ Stainless Steel ☐Other: ________

Condition of the top of casing: _____________________________

Measuring Point: ☐ Good ☐ Need Repair ☐ None Well Plug Vented?: ☐ Yes ☐ No

Well Plug Type: ☐ Compression ☐ Slip Cap ☐ Other: _______________

Well Plug Condition: ☐ Good ☐ Poor/Usable ☐ Needs Replacement

Lock Present: ☐ Yes ☐ No Condition: ☐ Good ☐ Poor

Does this well require a low profile, schedule 80 or other special plug?: Describe: ___________________________

Other Environmental Concerns?: ____

Comments: ____

Well ID: ________________________ Well Identification: ____

Well Pad: ____

Vault Type: ☐ Flush Mount ☐ Stick Up Description: ____________________________________

Brand: __________________ Size: ☐ 8-inch ☐ 12-inch ☐ Other: _____

Bolts: ☐ Two ☐ Three ☐ Four ☐ N/A Bolt Size: ☐ 9/16 ☐ 5/8 ☐ 1/2 ☐ 3/4 ☐Other: _____

Bolt Tab Condition: _________________________________ Gasket: ☐ Good ☐ Poor/Usable ☐ Missing

Condition of Vault Interior: ____

Well Size: ☐ 2-inch ☐ 4-inch ☐Other: _________ Well Casing: ☐ PVC ☐ Stainless Steel ☐Other: ________

Condition of the top of casing: _____________________________

Measuring Point: ☐ Good ☐ Need Repair ☐ None Well Plug Vented?: ☐ Yes ☐ No

Well Plug Type: ☐ Compression ☐ Slip Cap ☐ Other: _______________

Well Plug Condition: ☐ Good ☐ Poor/Usable ☐ Needs Replacement

Lock Present: ☐ Yes ☐ No Condition: ☐ Good ☐ Poor

Does this well require a low profile, schedule 80 or other special plug?: Describe: ___________________________

Other Environmental Concerns?: ____

Comments: ____

AECOM

Monitoring Well Development Log

Page ______ of ____

Date Started (yr/mo/day) ____________ Date Completed (yr/mo/day) ____________
Field Personnel ____________
Site Name ____________
Job # ____________
Well ID # ____________
_____ Upgradient _____ Downgradient
Weather Conditions ____________
Air Temperature ____________ °F

Total Well Depth (TWD) = ____________ 1/100 ft
Depth to Ground Water (DGW) = ____________ 1/100 ft
Length of Water Column (LWC) = TWD - DGW = ____________ 1/100 ft
1 Casing Volume (OCV) = LWC x _____ = ____________ gallons
5 Casing Volumes = ____________ gallons
Method of Well Development ____________
____
Total Volume of Water Removed ____________ gallons

Date/Time	Discharge Rate (gpm)	Volume Purged (gallons)	Water Temperature (°C)	pH	Eh	Specific Conductivity (µmhos/cm)	Turbidity/Color	Sand Content (%)	Remarks

COMMENTS/OBSERVATIONS: ____________

AECOM

Monitoring Well Development Log

Page 2 of 2

Well ID # ____________________

Date/Time	Discharge Rate (gpm)	Volume Purged (gallons)	Water Temperature (°C)	pH	ORP	Specific Conductivity (mS/cm)	Turbidity/Color	Sand Content (%)	Remarks

COMMENTS/OBSERVATIONS: ____________________

GROUNDWATER SAMPLING LOG

Date (mo/day/yr) ____________________

Field Personnel ____________________

Site Name ____________________

AECOM Job # ____________________

Well ID # ____________________

______ Upgradient ______ Downgradient

Weather Conditions ____________________

Air Temperature ____________________ ° F

Total Depth (TWD) Below Top of Casing = ______________ 1/100 ft

Depth to Groundwater (DGW) Below Top of Casing = ______________ 1/100 ft

Length of Water Column (LWC) = TWD - DGW = ______________ 1/100 ft

1 Casing Volume (OCV) = LWC x 0.163 = ______________ gal

3 Casing Volumes = ____________________ gal

Method of Well Evacuation ____________________

Method of Sample Collection ____________________

Total Volume of Water Removed ____________________ gal

Casing Diameter ____________________ inches

Casing Material ____________________

Measuring Point Elevation ____________________ 1/100 ft

Height of Riser (above land surface) ____________________ 1/100 ft

Land Surface Elevation ____________________ 1/100 ft

Screened Interval (below land surface) ____________________ 1/100 ft

Container	Analysis (Method)	# Bottles	Preservative	Dup - MS/MSD

FIELD ANALYSES

VOLUME PURGED (gallons)								
TIME (Military)								
Depth to Groundwater Below Top of Casing (ft)								
Drawdown (ft)								
pH (S.U.)								
Salinity (ppt)								
Sp. Cond. (mS/cm)								
Turbidity (NTUs)								
Dissolved Oxygen (mg/L)								
Water Temperature (°C)								
ORP (mV)								

Physical appearance at start Color ____________

Odor ____________

Sheen/Free Product ____________________

Physical appearance at sampling Color ____________

Odor ____________

Sheen/Free Product ____________________

COMMENTS/OBSERVATIONS ____

____

AECOM

GROUNDWATER SAMPLING LOG

Page ____ of ____

Site Name ____________________
AECOM Job # ____________________
Sample ID*

Date (mo/day/yr) ____________________
Field Personnel ____________________
Comments/Observations:

FIELD ANALYSES

VOLUME PURGED (gallons)											
TIME (Military)											
Water Level (ft BTOC)											
pH (S.U.)											
Sp. Cond. (mS/cm)											
Water Temp. (°C)											
Turbidity (NTUs)											
DO - (mg/L)											
Salinity (ppt)											
ORP (mV)											

FIELD ANALYSES

VOLUME PURGED (gallons)											
TIME (Military)											
Water Level (ft BTOC)											
pH (S.U.)											
Sp. Cond. (mS/cm)											
Water Temp. (°C)											
Turbidity (NTUs)											
DO - (mg/L)											
Salinity (ppt)											
ORP (mV)											

COMMENTS/OBSERVATIONS ____________________

AECOM

Calibration Log

Project Name: ____________________
Project Number: ____________________
Calibrated By: ____________________
Signature: ____________________

YSI 556 SN: ____________________
Turbidity Meter Model/SN: ____________________
Additional Equipment SN: ____________________
Date: ____________________

Operation Notes:
1) Turn meter on in Run mode and allow to warm up 10 to 15 minutes prior to calibration.
2) Observe DO % for 2-3 minutes when meter is initially turned on. The unit should display decreasing values until it is stabilized near 100%.
3) If the meter does not stabilize at/near 100%, indicates the DO sensor requires maintenance.

These values should be keyed in when calibrating a water quality meter. Be sure to use the temperature of the standards, not ambient temperature; and be sure the temperature sensor is submerged in the solution.

Table 1: Calibration Values At Various Temperatures

Temp. C	pH 4	pH 7	pH 10	Conductivity	ORP
5	4.00	7.07	10.19	896.00	257.00
10	4.00	7.06	10.16	1020.00	250.50
15	4.00	7.04	10.10	1147.00	244.00
20	4.00	7.02	10.05	1278.00	237.50
25	4.00	7.01	10.01	1413.00	231.00
30	4.00	6.99	9.96	1548.00	224.50

mm Hg = millimeters of mercury. Note that the YSI 556 uses this information ONLY when the DO calibration is being done. After calibration is complete it no longer corrects for pressure change. Verify the meter is correct for your altitude when calibrating.

Table 2: Atmospheric Pressure / Altitude Table

Altitude feet (asl)	Pressure (mmHg)	Altitude feet (asl)	Pressure (mmHg)	Altitude feet (asl)	Pressure (mmHg)
0	760	1126	730	2290	699
278	752	1413	722	2587	692
558	745	1703	714	2887	684
841	737	1995	707	3190	676

Table 3: DO % Saturation Vs. Temperature

Temp C.	DO	Temp C.	DO	Temp C.	DO	Temp C.	DO	Temp C.	DO
15	10.084	20	9.092	25	8.263	30	7.559	35	6.950
16	9.870	21	8.915	26	8.113	31	7.430	36	6.837
17	9.665	22	8.743	27	7.968	32	7.305	37	6.727
18	9.467	23	8.578	28	7.827	33	7.183	38	6.620
19	9.276	24	8.418	29	7.691	34	7.065	39	6.515

YSI 556 Calibration

Parameter	Before Calibration	After Calibration	Time	Units
Barametric Pressure		▨		mmHg
Temperature (Saturated Air)				C
Temperature (Calibration Solution)				C
DO				mg/L
pH 7				SU
pH 4				SU
pH 10				SU
Specific Conductance				mS/cm
ORP				mV

MicroTPW Calibration

Calibrations performed 0.02, 10, and 1,000 NTU	Calibrations accepted: Yes No circle one

Calibration Solutions

Parameter	Manufacturer	Sandard	Lot #	Expiration
pH 4.00		4.00 SU		
pH 7.01		7.01 SU		
pH 10.06		10.06 SU		
Specific Conductivity		1.413 mS/cm		
ORP		237.5 mV		
Turbidity		0.02 NTU		
Turbidity		10 NTU		
Turbidity		1,000 NTU		

Field Data Log For Soil Boring

Event #:

Back to List

Date	
Field Personnel	
Sample ID	
Site Name	
Earth Tech Job No.	
Air Force ID	
Location Type Code	
Weather Conditions	
Air Temperature (F)	

Method of Sample Collection

○ Discrete ○ Composite

○ Encore ○ Stainless-Steel

Borehole Diameter (inches)	
Construction Method	
Depth to Bottom of Borehole (feet)	
Gradient Type	
Ground Elevation (feet)	

Location Description

Comments/Observations

AECOM

Chain of Custody and Analytical Request

Page _______ of _______
Project Number: ________________
WBS Number: ________________
Chain of Custody Number[1]: ________________
LIMS Number: ________________

Facility / Air Force Base ID:

Project Name / Site Name:

Client Name:

Collected by:

								Sample Analysis Requested[5]									Quality Assurance Samples[6]			
Field Sample ID (30 Characters Max)	ERPIMS LOCID (15 Characters Max)	Date Collected (dd-mmm-yyyy)	Time Collected (Military) (hhmm)	Sample Depth (beginning - ending)	SA Code[2]	Sample Number[3]	Sample Matrix[4]	Number of containers									Ambient Blank Lot Control Number	Equipment Blank Lot Control Number	Trip Blank Lot Control Number	Cooler ID
				-																
				-																
				-																
				-																
				-																
				-																
				-																
				-																
				-																
				-																
				-																
				-																
				-																

Comments____
____
____

Custody Transfers Prior to Receipt by Laboratory

Relinquished By (Signed)	Date	Time	Received by (signed)	Date	Time
1.____________________________			1.____________________________		
2.____________________________			2.____________________________		
3.____________________________			3.____________________________		

Sample Delivery Details / Laboratory Receipt

Delivered Directly to Lab: _____________ Shipped: ______________________
Method of Shipment:__________________ Airbill #:______________________
Analytical Lab:______________________ Location:______________________
Lab Recipient:______________________ Date:_________ Time:_________

1.) Chain of Custody Number = date collected + custody number (e.g. 09-02-1999-01)

2.) Sample Type (SA) Codes: N = Normal Sample, TB = Trip Blank (-c) Sample, FD = Field Duplicate (-a) Samples, FR = Field Replicate (-b) Samples, EB = Equipment Blank (-d) Samples, MS = Matrix Spike Samples, SD = Matrix Spike Duplicate Samples

3.) Sample Number: Unique sample number collected from a particular location per day. (e.g. Groundwater sample collected from MW-1 on 10/10/99 = 01, if sampled again on 10/10/99 = 02, etc.)

4.) Matrix Codes: GS = Soil Gas, WG = Groundwater, WS = Surface Water, SO = Soil, SE = Sediment, SL = Sludge, SS = Surface Soil Samples, WQ = Aqueous Blank Samples (trip, equipment, ambient, etc), SQ = Soil Blanks

5.) Sample Analysis Requested: Analytical method requested and number of containers provided for each.

6.) Quality assurance samples are assigned by date (ddmmyy) and the sample number associated with the sample (01, 02, etc) (e.g. Equipment blank collected in association with MW-1 on 10/10/99 will be designated 10109901 in the Equipment Blank Lot Control Number field).

Page _____ of _____

IDW MANAGEMENT FORM

PROJECT: ______________________________

SITE NAME: ______________________________

LOCATION: ______________________________

CONTAINER NUMBER	MEDIA DESCRIPTION	MEDIA ORIGIN	DATE FILLED	DATE SAMPLED	DATE DISPOSED	COMMENTS

Drill Rig Inspection Checklist

Date	Equipment Model/Type:
Project Name:	Serial or License #
Project #	Location Owner/Operator:
Project Manger:	Inspector:

Place a (✓) in the "Yes" column if the requirement has been met. If a "No" is encountered, equipment must be removed from operation until the deficiency has been corrected. Describe deficiencies on page two of this form. Use the Comment column to note any additional information needed to certify the equipment. If a checklist item is found to be "Not Applicable," check "NA" and provide a comment in the appropriate box.

Item Name	Requirement	Yes	No	NA	Comment
Hydraulic systems controls and levers	No leak fittings or connections. Levers are in good operating condition. Fluid levels are full.				
Fuel, oil, water, and coolant lines	No leaks.				
Hoses	No leaks in hoses or connections. No signs of excessive wear, kinked or bent hoses.				
Gauges	Operational and visible to operator.				
Emergency kill switch and life line	Operational and accessible to operator.				
Shear pins	In place.				
Drive chains	No signs of excessive wear, broken or defective links.				
Parking brakes	Set and operational.				
Outriggers	No leaks. Set on pads (as necessary to avoid damage).				
Windshield Wipers	Operational.				
Lights (head, tail and running lights)	Operational and without cracked lenses.				
Back-up alarm	Operational, spotter used.				
Cables and ropes	No fraying, birdnesting, flattening, stretching. Must be braided or properly clamped at connections.				
Pulleys, drums and spools	No excessive wear or cracking.				
Derrick/Mast	Locked in position. Frame is not cracked or bent.				
Hoists	Properly spooled cable, rated to lift loads.				

Item Name	Requirement	Yes	No	NA	Comment
Safety equipment	Safety harness, fire extinguisher, flares, safety reflectors, first aid kit, grounding wire for fueling, and spill response equipment (for fueling and repairs).				
Guards	Power take-offs (PTOs) and all rotating parts designed with guards. Guards must have warning labels.				
Miscellaneous (as applicable)	Diverter systems; auger and head seals; cyclones; grout plant guards; etc. (list): • • •				

DEFICIENCIES (Explain all negative response and list corrective actions; all deficiencies must be corrected before the rig is entered into service):

1.
2.
3.
4.
5.

Other Repairs, Routine Maintenance and/or Comments:

Inspection Conducted and Certified by:

	Print Name:	Signature	Date:
Owner / Operator			

Checklist Reviewed by:

	Print Name:	Signature	Date:
Earth Tech PM or SSO			

HTW DRILLING LOG

HOLE NO.:

SHEET
OF SHEETS

1. COMPANY NAME

2. DRILLING SUBCONTRACTOR

3. PROJECT

4. LOCATION

5. NAME OF DRILLER

6. MANUFACTURER'S DESIGNATION OF DRILL

7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT

8. HOLE LOCATION

9. SURFACE ELEVATION

10. DATE STARTED

11. DATE COMPLETED

12. OVERBURDEN THICKNESS

15. DEPTH GROUNDWATER ENCOUNTERED

13. DEPTH DRILLED INTO ROCK

16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED

14. TOTAL DEPTH OF HOLE

17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES

20. SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21. TOTAL CORE RECOVERY %

22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23. SIGNATURE OF INSPECTOR

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

PROJECT

HOLE NO.

HTW DRILLING LOG

HOLE NO.:

PROJECT

INSPECTOR

ELEV. a	DEPTH b	DESCRIPTION OF MATERIALS c	FIELD SCREENING RESULTS d	GEOTECH SAMPLE OR CORE BOX NO. e	ANALYTICAL SAMPLE NO. f	BLOW COUNTS g	REMARKS h

APPENDIX B

SOPs / Methods

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Alabama Environmental Investigation and Remediation Guidance

Revised September 2005

ALABAMA ENVIRONMENTAL INVESTIGATION AND REMEDIATION GUIDANCE

A COMPREHENSIVE GUIDANCE DOCUMENT PREPARED FOR ALABAMA INDUSTRIES OR INDIVIDUALS INVOLVED IN ENVIRONMENTAL ASSESSMENT, INVESTIGATION, AND REMEDIATION PROJECTS BY THE ALABAMA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

March 2002
Revised October 2002
Revised September 2005

NOTICE

This document has been prepared to assist individuals in understanding the necessary elements of environmental investigations and remediation projects. It is not intended as a substitute for the regulations and should not be used as such. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ALABAMA ENVIRONMENTAL INVESTIGATION AND REMEDIATION GUIDANCE

TABLE OF CONTENTS

1.0 INTRODUCTION

This guidance document presents a comprehensive statement of the requirements for performing environmental investigations and remediation projects in Alabama. These requirements generally represent the Alabama Department of Environmental Management's (ADEM's) expectations necessary for complete investigations and remediation projects for programs that manage contamination from hazardous constituents, hazardous waste, petroleum products, and/or petroleum wastes. Various programs administered by ADEM, which require investigation, monitoring and/or remediation, may have areas in which different or more specific requirements apply. This guidance document is designed to be used strictly as an aid in the development of adequate environmental investigations and remediation projects by individuals with the appropriate technical expertise and skill. This guidance document is not intended to be used as a substitute for existing program regulations and should not be used as such. Certain submissions required by ADEM involve the practice of engineering and/or land surveying, as those terms are defined in Code of Alabama 1975, as amended, § 34-11-1 to 34-11-37; and/or the practice of geology, as that term is defined in Code of Alabama 1975, as amended, § 34-41-1 to 34-41-24. It is the responsibility of any person preparing or submitting such information to ensure compliance with these laws and any regulations promulgated there under, as may be required by the State Board of Registration for Professional Engineers and Land Surveyors and/or the Alabama Board of Licensure for Professional Geologists. All submissions, or parts thereof, which are required by State law to be prepared by a licensed engineer, land surveyor, or geologist, must include the engineer's, land surveyor's, and/or geologist's signature and/or seal, as required by the applicable licensure laws.

2.0 PRELIMINARY INVESTIGATION

2.1 Section Outline

2.2 Purpose of a Preliminary Investigation

A Preliminary Investigation is conducted to gain information about the site, confirm or deny that a release(s) of constituents of potential concern (COPCs) has occurred, and to determine what potential receptors exist in the area.

2.3 Elements of Preliminary Investigation Activities

A Preliminary Investigation Work Plan should be developed and, if required by a specific regulatory program, submitted to ADEM. The plan should include a detailed discussion of all applicable issues outlined in this section. The performance of the Preliminary Investigation should, at a minimum, include the following activities:

2.3.1 Surrounding Land Use - An accurate description of the surrounding land use should be made and should include, at a minimum, the following information:

(a) The type of surrounding population (rural vs. urban, residential vs. industrial vs. commercial, and population density),

(b) The location of the site [physical address, mailing address, latitude and longitude in decimal degrees with precision of six significant digits to the right of the decimal; and topographic map location (section, township and range)],

(c) A site map developed with information which includes, but is not limited to, all known:

  i. Areas of concern (AOCs),

ii. Monitoring wells,
iii. Sampling sites,
iv. Drainage patterns,
v. Utilities,
vi. Buildings,
vii. Property Boundaries,
viii. North Arrow, and
ix. All Private & Public Supply Wells.

2.3.2 Well Inventory - A complete well inventory, both public and private, should be conducted within a 1 mile radius of the site using publicly available resources (*i.e.*, local water supply authorities, ADEM's Public Water Supply Branch, United States Geological Survey, Geological Survey of Alabama, etc.). Any pertinent information gleaned from a door-to-door survey of all residents within 500 feet of the property boundaries or as otherwise directed by the Department should also be included. Also, a determination should be made to identify if the site is located within a source water assessment area. Information on each identified well should include the following:

(a) The owner of well,
(b) The depth of well,
(c) The aquifer of production,
(d) The use of well,
(e) The screened interval, and
(f) The depth to groundwater.

2.3.3 Surface Water Intake Inventory - A complete inventory of surface water intakes including both the potable springs and the surface water intakes should be conducted within a 1 mile radius of the site using publicly available resources (*i.e.*, local water supply authorities, ADEM's Public Water Supply Branch, United States Geological Survey, Geological Survey of Alabama, etc.). Any pertinent information gleaned from a door-to-door survey of all residents within 500 feet of the property boundaries or as otherwise directed by the Department should also be included. Also, a determination should be made to identify if the site is located within a source water protection area.

2.3.4 Surface Water Locations - The locations of all surface water bodies that may potentially be impacted by the subject property should be determined with a review of topographic or other area maps. Use classification(s) of surface water stream(s) are listed in ADEM Division 6 Regulations.

2.3.5 Records Search - A thorough records search concerning the current and historical activities and processes used on site should be conducted. The search should include an inventory list of all chemicals stored and used onsite. The search should also include an inventory list of all types of wastes produced, managed, and/or disposed onsite. These inventory lists will be essential in the determination of constituents of potential concern (COPCs). The identification of COPCs is necessary in determining a sampling or analysis strategy. The inventory list of chemicals used and/or wastes produced onsite should be compared with constituents listed in program-specific regulations to determine which, if any, may be of potential concern.

2.3.6 **Utilities Search** - A thorough utilities survey should be conducted to identify and delineate all utilities that cross under the site or that are adjacent to the property. The utilities to be delineated should include sanitary sewers, storm sewers, water lines, electrical lines, gas lines, phone lines, or other utility lines. The delineation can be accomplished through use of “Line Locator” services, local utility personnel, personal communication with owner, ground penetrating radar, or other similar methods.

2.3.7 **Sampling Strategy** - A sampling strategy should be determined for each type of media to be sampled.

(a) The soil sampling strategy should include the following:

i. Soil sampling should be conducted in a manner expected to produce the maximum concentration of COPCs such as at the release point, within the visually observable area of contamination, and along potential migration pathways (*i.e.,* utilities).

ii. A minimum of 4 soil borings for the collection of surface soil samples and subsurface soil samples should be conducted. (See Appendix C)

iii. To establish background surface and subsurface soil conditions (i.e.: for inorganic contamination or if a potential source of COPCs are up gradient of the site)), a minimum of 4 soil borings should be collected in an area up gradient from and unaffected by facility operations. The arithmetic mean of the results of the soil samples should be used as the background soil concentration for the respective sampling interval.

iv. Soil borings should be extended to obtain samples that represent the zones most likely to have been impacted.

v. Soil borings should be extended to the top of the first continuous zone of saturation under the site or to bedrock if no groundwater is encountered. If it is determined that the water table or bedrock exists at significantly excessive depths, the Department should be notified for assistance.

vi. Soil samples should be collected in accordance with the methods outlined in Appendix C of this document. All soil samples should be analyzed in accordance with USEPA approved methods included in the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Method, SW-846 (latest edition) or others.

vii. A minimum of 4 surface soil samples should be collected. All surface soil samples should be collected as grab samples and collected within the uppermost 12-inches of soil. All surface soil samples should be analyzed for the COPCs using Method Detection Limits (MDLs) that are less than or equal to ADEM’s Preliminary Screening Values (PSVs) developed in accordance with Section 4.0 of this document.

viii. Subsurface soil samples should be taken at no more than 5-feet intervals from each boring. All subsurface soil samples should be field screened (*i.e.,* PID, HNU, XRF, and color-metric), and a minimum of 3 subsurface soil samples per boring (if possible) should be collected for laboratory analysis. The 3 subsurface soil samples should include, at a minimum, 2 samples exhibiting high field screening levels and 1 sample just above the water table. If soil borings are greater than 50 feet in depth, additional subsurface soil samples should be collected for laboratory analysis. All subsurface soil samples should be analyzed for COPCs using MDLs that are less than or equal to ADEM's PSVs selected in accordance with Section 4.0 of this document.

ix. All surface soil samples should be obtained by using appropriate equipment such as spoons, shovels, hand-augers, push tubes, and post-hole diggers. Surface soil samples may also be collected in conjunction with the collection of subsurface soil samples using mechanical drilling equipment and/or ADEM approved specialized sampling equipment (Appendix C).

x. All subsurface soil samples should be obtained using appropriate equipment such as Shelby Tubes, split spoon samplers or other specialized samplers (direct push technologies, EnCore^{TM} Samplers, etc.) (Appendix C). The use of specialized samplers should be approved by ADEM prior to initiating all assessment activities. Auger cuttings are not appropriate.

xi. Quality Assurance/Quality Control procedures, and decontamination procedures outlined in Appendices D and E should be utilized to ensure sample quality.

xii. All Investigation-Derived Waste (IDW) should be collected, properly contained and stored, sampled and analyzed for a waste determination, and properly disposed of as outlined in Appendix D and in accordance with the ADEM Regulations.

xiii. All analysis collected should be compared to the Preliminary Screening Values identified in Section 4.0 of this document.

(b) Installation of Groundwater Monitoring Wells should meet the following criteria:

i. Groundwater flow direction should be determined after the installation of 3 piezometers or Type-I Temporary Monitoring Wells. All piezometers or Type-I Temporary Monitoring Wells should be installed in accordance with design, construction and installation criteria addressed in Appendix B of this document.

ii. Based on the groundwater elevation/potentiometric surface data collected from the piezometers or Type-I Temporary Monitoring Wells, a minimum of one permanent up gradient well located in an area that has not been impacted by the release or the site's activities should be installed.

iii. Typically a minimum of 3 permanent wells, located immediately down-gradient of the unit, structure, and/or at the release point, is appropriate.

iv. All permanent wells should be screened in the first saturated zone (or water-bearing zone) below the ground surface, or first saturated zone (or water bearing zone) below the unit or structure under investigation. All permanent wells should have a maximum screened interval of 10-feet, and should be placed at the appropriate interval to detect the COPCs. Nested well systems may be warranted and should be used if determined to be necessary.

v. All permanent monitoring wells should be installed, constructed and developed in accordance with the appropriate drilling and monitoring well installation techniques (See Appendix B).

(c) The collection of groundwater samples and of flow measurements should adhere to the following procedures:

i. Groundwater samples should be collected from all permanent monitoring wells installed and analyzed for the COPCs.

ii. Groundwater samples should be collected in accordance with the approved methods documented in Appendix C of this document.

iii. All groundwater samples should be analyzed using an USEPA approved methods included in the USEPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Method, SW-846 (latest edition) with Method Detection Limits that are less than or equal to ADEM’s Preliminary Screening Values selected in accordance with Section 4.0 of this document.

iv. Quality Assurance/Quality Control and decontamination procedures outlined in Appendices D and E of this document should be utilized to ensure sample quality.

v. All Investigation-Derived Waste (*i.e.,* groundwater and decontamination fluids) collected during the development and purging activities should be contained and disposed of as outlined in Appendix D and in accordance with the ADEM Regulations.

vi. A survey of the site should be conducted to establish well elevations, groundwater elevations, and ground elevations at each well, the locations of key structures, and the location of the release. The survey datum should be site-specific and based on a USGS established benchmark or interpolated from a topographic map. Survey datum established to 100 feet artificial benchmark is not appropriate.

(d) Surface water sampling should be conducted to collect representative sample(s) of the affected or potentially affected surface water(s) of interest. The sampling techniques and equipment should minimize effects on the integrity of the sample. The physical characteristics of the location of the person conducting the sampling should dictate the type of sampling equipment to be used in the sampling event. Surface samples can be taken by directly dipping of the sample container into the water body. This can be done from a boat, pier, bridge or wading [Wading is appropriate if the water body has a noticeable current and the sample is collected in such a manner as to prevent biasing by the re-suspension of bottom sediments]. Various types of primary sampling equipment such as peristaltic pumps, discreet depth samplers, bailers, buckets and supplemental equipment may be necessary as conditions dictate.

For flowing water situations, samples should be collected from a minimum of three locations. If possible, the first sample should be collected downstream of an area of actual or suspected release, the second sample collected at the point of the actual or suspected release, and the third sample should be collected upstream of the area of the actual or suspected release. The upstream sample should be used to determine background levels [If an upstream sample is unattainable, a nearby site that has not been affected by the release should be used]. Estuarine area samples are normally collected on successive slack tides. For water bodies that have a tendency to stratify and lack the mixing characteristics of flowing waters (*i.e.,* lakes, ponds, surface impoundments etc.), the number of samples will be dependent upon the scope of the investigation. The following factors should be considered when conducting a surface water sampling event:

i. Water use;
ii. Point source discharges;
iii. Nonpoint source;
iv. Tributary locations;
v. Changes in stream characteristics;
vi. Type of streambed;
vii. Depth of stream, pond, lake, etc.;
viii. Turbulence;
ix. Presence of structures (weirs, dams, etc.);
x. Accessibility; and
xi. Tidal effect (estuarine).

(e) Sediment sampling should be conducted to collect representative sample(s) from affected or potentially affected surface water bodies. The physical characteristics of the location of the person conducting the sampling should dictate the type of sampling equipment to be used in the sampling event. Wading is the preferred method for reaching shallow flowing water sampling locations. A number of sediment samples should be collected along a cross section of a water body in order to characterize the bed material.

The factors that should be considered when conducting a sediment sampling event are the same as used when conducting a surface water sampling event.

2.3.8 Emergency Response and Free Product Recovery - Procedures for emergency response and free product recovery include, but are not limited to, the following:

(a) If free product is encountered or an immediate threat to human health and the environment occurs, free product recovery and emergency response activities should be implemented immediately.

(b) Results of the free product recovery and emergency response activities should be reported to ADEM in accordance with the applicable regulatory program.

(c) All free product recovery and emergency response activities should be conducted until all free product has been completely recovered, to the maximum extent possible and/or technically feasible; and/or the immediate threat to human health and the environment has been eliminated. Affected programs (RCRA, CERCLA, UST, Industrial, UIC, etc.) should be referred for specific recovery, remediation, and/or discharge requirements.

(d) Recovery of contaminated runoff should be conducted to the maximum extent possible, and/or technically feasible; and/or the immediate threat to human health and the environment has been eliminated. Affected programs (RCRA, CERCLA, UST, Industrial, UIC, etc.) should be referred to for recovery, remediation, and/or discharge requirements.

2.3.9 Management of Investigation-Derived Waste (IDW) - The management of all investigation-derived waste (i.e.: soil cuttings, groundwater, decontamination fluids, etc.) generated during the Preliminary Investigation should include both the collection and the containment of such wastes. A waste determination should be performed in order to determine the proper handling and disposal procedures. All wastes should be disposed of as outlined in Appendix D and in accordance with the ADEM regulations.

2.4 Submission of a Preliminary Investigation Report

A **Preliminary Investigation Report** should be developed and submitted to ADEM for review at the conclusion of the preliminary investigation. The Preliminary Investigation Report should include a detailed description of all investigation activities and information recommended by this guidance.

3.0 COMPREHENSIVE INVESTIGATION

3.1 Section Outline

3.2 Purpose of a Comprehensive Investigation

A Comprehensive Investigation is conducted in order to determine the full horizontal and vertical extent of contamination (soil and groundwater) and/or free product plume in all media. A Comprehensive Investigation is necessary when the results of the Preliminary Investigation confirm that contamination is present in any environmental media.

3.3 Elements of a Comprehensive Investigation Work Plan

Prior to beginning a Comprehensive Investigation, a work plan should be developed. The plan should include detailed discussions of, at a minimum, all of the activities described below under soil investigation, groundwater investigation, and management of investigation-derived waste. Refer to the applicable regulatory requirements for the specifics on the submittal of this plan to the Department.

At the conclusion of the Comprehensive Investigation, a Comprehensive Investigation Report should be developed and submitted to ADEM in accordance with the applicable regulatory requirements. The Comprehensive Investigation Report should include a detailed description of all investigation activities conducted at the site outlined in the Site Investigation Report checklist (Figure 2). In addition to the copies of all original laboratory reports the Comprehensive Investigation Report should include electronic version of all analytical data (past and present) obtained from each monitoring well. This data should be compiled and reported to the Department in a spreadsheet format.

If a previous Preliminary Investigation Report was not submitted to ADEM prior to initiation of any comprehensive investigation activities, the Comprehensive Investigation Report should also include a summary of all investigation activities conducted, with all respective soil boring logs, monitoring well diagrams, analytical data, and laboratory reports with copies of completed chain-of-custody forms.

3.4 Elements of a Comprehensive Investigation

A Comprehensive Investigation should include, at a minimum, the following elements:

3.4.1 Soil Sampling - A systematically designed soil sampling investigation should be conducted in order to define the horizontal and vertical extent of contamination in soils. All soil borings should be extended to obtain samples that represent the zones most likely to have been impacted. Consequently, all soil borings should be extended to the water table or to bedrock if no water is encountered. If it is determined that the water table or bedrock exists at significantly excessive depths, an alternative soil sampling plan should be developed and submitted to ADEM for review and approval.

All soil samples should be collected in accordance with the appropriate soil sampling methods outlined in Appendix C of this document. All soil samples should be analyzed in accordance with the USEPA approved methods included in the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Method, SW-846 (latest edition) or other methods approved by the Department.

Surface soil samples should be obtained from all borings drilled and should be collected from between the surface and 12-inches below ground surface. All surface soil samples should be collected as grab samples and should be analyzed for the COPCs.

Surface soil samples may be obtained by using spoons, shovels, hand-augers, push tubes, or post-hole diggers. Surface soil samples may also be collected in conjunction with the collection of subsurface soil samples using heavy mechanical drilling equipment and/or ADEM approved specialized sampling equipment (Appendix C).

Subsurface soil samples should be taken from each boring at no more than five-foot intervals and should be field screened (PID, HNU, XRF, and color-metric). A minimum of three subsurface soil samples per boring (if possible) should be collected for laboratory analysis. The three subsurface soil samples should include, at a minimum, two samples exhibiting high field screening levels and one sample just above the water table. If soil borings are greater than 50 feet in depth, additional subsurface soil samples should be collected for laboratory analysis. All subsurface soil samples should be analyzed for the COPCs.

In order to expedite the assessment process, specialized sampling methods can be used to obtain subsurface soil samples. Specialized sampling methods and tools, which can be utilized, include immunoassay analyses, soil vapor survey, and field gas chromatographs. Appendix C of this guidance document includes detailed discussions of various field screening methods. The use of specialized samplers should be approved by ADEM prior to initiating all assessment activities.

Quality Assurance/Quality Control procedures (Appendix D), and EPA required decontamination procedures (Appendix E) should be utilized to ensure sample quality.

3.4.2 Groundwater Sampling - A systematically designed groundwater investigation should be conducted in order to define the horizontal and vertical extent of contamination. Site-specific hydrogeologic conditions should be determined at the sites or area of concern. Potential interconnection of an overlying aquifer or saturated zone with the next deeper aquifer or saturated zone should be established. The hydrogeologic conditions and interconnection potential should be established by all previous and proposed soil borings, all previous and proposed monitoring wells, hydraulic tests (slug and pump tests), geophysical survey investigations, and/or dye trace studies. If hydrogeologic conditions justify the need for a dye trace study (karst and highly fractured environments) and/or there is a potential risk to a public supply well or a significant spring, which is utilized as a public water supply, a dye trace study should be conducted to establish if a migration pathway from the area of contamination and the public supply well or spring does exist.

Installation of a sufficient number of permanent monitoring wells down-gradient is necessary to determine the horizontal extent of contamination. All permanent monitoring wells should be screened in the same saturated zone, water bearing zone, or stratigraphic interval currently being monitored in the previous monitoring wells installed during the Preliminary Investigation.

At a minimum, one permanent monitoring well should be located within the source release area. It should be screened in an interval beneath the shallower contamination plume and show no evidence of contamination. Due to site-specific hydrogeologic and groundwater quality conditions encountered during the Preliminary Investigation, additional deep permanent monitoring wells or well nests may be necessary to verify that the vertical extent of the contamination plume has been adequately investigated down-gradient of the contamination source area.

Field screening methods, such as direct push technologies, can be used to locate monitoring wells more effectively, and to significantly expedite the assessment process. However, these methods are only to be used as field screening tools with the results verified by the advancement of soil borings and the installation of permanent monitoring wells that meets the monitoring well design requirements discussed in this guidance document. Appendix C of this guidance document includes detailed discussions of various field screening methods.

A sufficient number of permanent monitoring wells should be installed to define the horizontal and vertical extent of any free product plume (LNAPL and DNAPL). A sufficient amount of monitoring wells should be installed within the free product plume to monitor the effectiveness of any free product recovery efforts. All permanent wells should be installed and screened to adequately establish the thickness of the free product plume.

All permanent monitoring wells should be installed, constructed, and developed in accordance with the acceptable procedures described in Appendix B of this guidance document.

Groundwater samples should be collected from all permanent groundwater monitoring wells installed and in accordance with the procedures outlined in Appendix C of this document. All samples should be analyzed for Constituents of Potential Concern

(COPCs) using the analytical methods included in the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Method, SW-846 (latest edition). Any analytical method utilized should be capable of using MDLs that are less than or equal to the Preliminary Screening Values developed in accordance with Section 4 of this document. Quality Assurance/Quality Control procedures identified in Appendix D should be utilized to ensure sample quality.

All monitoring wells installed during the Comprehensive Investigation should be surveyed to establish top of casing elevations, ground elevations and latitude and longitude. All surveys should be conducted to an established datum that is site-specific and based on a USGS established benchmark or interpolated from a topographic map. Survey datum established to a 100-feet artificial benchmark is not appropriate. Monitoring wells may be located utilizing GPS technology.

A determination of the groundwater flow direction and rate should be made. A sufficient number of slug tests (slug in and slug out) or an aquifer pump test should be conducted to establish the hydraulic characteristics of the uppermost aquifer (transmissivity, storativity, porosity, leakage, hydraulic gradient, hydraulic conductivity, and flow rate).

A groundwater monitoring schedule should be designed in accordance with regulatory requirements. During the first year of groundwater monitoring, Groundwater Monitoring Reports should be developed and submitted to ADEM. The Groundwater Monitoring Reports should include:

(a) Description of all sampling activities conducted,

(b) Conclusions and interpretations drawn from the sampling event and analytical results,

(c) A site map illustrating the location of all monitoring wells on site and off site,

(d) A potentiometric map of the site illustrating the groundwater elevations at each well and the groundwater flow direction,

(e) A site map illustrating the contamination plume and analytical results for the COPCs,

(f) A table documenting all water levels and total depth of all wells measured, top of casing elevations, and groundwater elevations,

(g) The original laboratory reports obtained from the contracted laboratory,

(h) A table of current and historical groundwater analytical data obtained, and

(i) All completed chain-of-custody forms.

3.4.3 Surface Water Sampling - A surface water investigation should be conducted If it is determined that a surface water body (rivers, streams, creeks, lakes, ponds, impoundment, wetlands and estuaries) is threatened or has been impacted by a release, a complete investigation of that surface water body should be conducted. The investigation should include, at a minimum, the following information:

(a) Water use;

(b) Point source discharges;

(c) Nonpoint source discharges (springs, seeps, storm-water runoff points, etc.);

(d) Tributary locations;

(e) Changes in stream characteristics;

(f) Type of streambed;

(g) Turbulence;

(h) Presence of structures (weirs, dams, etc.);

(i) Tidal effect (estuarine);

(j) The width and depth;

(k) The flow velocity;

(l) Surface water sampling upstream, downstream and at intermediate stations along the length of the potentially effected area of a stream, and when major changes occur in a stream reach;

(m) Surface water sampling from any pond, lake, and impoundment potentially impacted;

(n) Surface water sampling from estuarine or wetland areas potentially impacted;

(o) If the site or sites is located within a complex hydrogeologic setting (*i.e.,* karst and fractured flow environments), a dye trace study should be conducted to identify all direct migratory pathways from the site to all potential surface water bodies in the area.

All surface water samples should be collected in accordance with the procedures outlined in Appendix C of this document. All samples should be analyzed for the COPCs using the analytical methods included in the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Method, SW-846 (latest edition) or other ADEM approved methods. Quality Assurance/Quality Control procedures identified in Appendix D of this document should be utilized to ensure sample quality.

3.4.4 Sediment Sampling - A sediment investigation should be conducted if the determination is made that a release to a surface water body may have occurred. Sediment samples should be collected during the time of all surface water sampling activities, and at all surface water sample locations (if possible).

All sediment samples should be collected in accordance with the procedures outlined in Appendix C of this document. All samples should be analyzed for the COPCs using the analytical methods included in the EPA document Test Methods for Evaluating Solid Waste, Physical/Chemical Method, SW-846 (latest edition) or other ADEM approved methods. Quality Assurance/Quality Control procedures identified in Appendix D of this document should be utilized to ensure sample quality.

3.4.5 Management of Investigation-Derived Waste (IDW) - The management of all IDW (i.e.: soil cuttings, groundwater, and decontamination fluids) generated during the Comprehensive Investigation should include both the collection and the containment of such wastes. A waste determination should be performed in order to determine the proper handling and disposal procedures. All wastes should be disposed of as outlined in Appendix D and in accordance with the ADEM regulations.

3.5 Submission of a Comprehensive Investigation Report

A **Comprehensive Investigation Report** should be developed and submitted to ADEM for review at the conclusion of the comprehensive investigation. The Comprehensive Investigation Report should include a detailed description of all investigation activities and information collected under this section or, if applicable, in accordance with specific ADEM program requirements.

4.0 RISK ASSESSMENT

4.1 Section Outline

4.2 Purpose

At the completion of the Comprehensive Investigation, a sufficient amount of data should be available to support an assessment of baseline risks to human and ecological receptors. The risk assessment is intended to provide regulatory and site managers with information to:

1. Determine risk-based target levels (RBTL's) (i.e.: remediation levels) of contaminants of concern that can remain on-site and still be protective of human health and the environment;

2. Provide data to evaluate remedial alternatives for potential impacts to human health and the environment;

3. Effectively document and communicate to the public risks associated with contaminated properties.

4.3 Preliminary Screening Values

It is common for environmental risk assessments to begin with a comparison of site-specific contaminant concentrations to Preliminary Screening Values (PSVs). PSVs are conservative health-based concentrations of hazardous constituents determined to be indicators for the protection of human health or the environment. The detection of a contaminant(s) at a concentration greater than a PSV does not necessarily trigger a requirement to perform remediation. Conversely, the absence of chemical concentrations greater than PSVs does not necessarily mean that no further investigative or remedial action is warranted. These decisions should be made on a case-by-case basis. PSVs simply provide a general and rapid measure of the overall risk to human health and the environment associated with a contaminated site. PSVs can, in most cases, be utilized as default remediation levels because they are based on highly conservative exposure assumptions. PSVs should be developed for all effected media in accordance with the following:

4.3.1 Groundwater - PSVs for constituents in groundwater are equivalent to the Maximum Contaminant Levels (MCLs) as listed in ADEM Admin. Code R. 335-7-2 (Primary

Drinking Water Standards) and as listed by the USEPA (http://www.epa.gov/waterscience/drinking/standards/dwstandards.pdf). For constituents where there is not an MCL, PSVs should be consistent with the most current version of the USEPA Region IX Preliminary Remediation Goals (PRGs) for Tap Water (http://www.epa.gov/region09/waste/sfund/prg/index.htm). As a caveat, it should be noted that the Department recommends the use the of a hazard quotient (HQ) of 0.1. The Region IX PRGs utilize a HQ of 1.0. In order to use the ADEM recommend value(s), all constituents listed on the Region IX PRG table that were calculated based on their non-carcinogenic effects should be divided by a factor of 10 in order to properly reflect a HQ of 0.1. Table 2-2 located with the current version of the Alabama Risk-Based Corrective Action (ARBCA) document reflects the appropriate HQ and may be used to minimize any errors made when utilizing the groundwater PSVs.

4.3.2 **Surface Water** – PSVs for surface water should be consistent with the Alabama Water Quality Criteria (ADEM Admin. Code R. 335-6-10). For constituents where there are no Water Quality Criteria values, PSVs should be consistent with those for groundwater.

4.3.3 **Ambient Air** - PSVs for ambient air should be consistent with USEPA Region IX PRGs.

4.3.4 **Soils** - PSVs for soil must address several specific exposure routes that must be evaluated individually: (1) ingestion, (2) inhalation, (3) dermal contact and (4) the protection of groundwater (leachability). PSVs to address ingestion, inhalation and dermal contact should be consistent with the USEPA Region IX PRGs for the appropriate exposure scenarios. It is also appropriate to utilize the value that combines the direct exposure pathways (ingestion, inhalation, and dermal contact) for the appropriate use scenario (residential vs. industrial). As a caveat, it should be noted that the Department recommends the use the of a hazard quotient (HQ) of 0.1. The Region IX PRGs utilize a HQ of 1.0. In order to use the ADEM recommend value(s), all constituents listed on the Region IX PRG table that were calculated based on their non-carcinogenic effects should be divided by a factor of 10 in order to properly reflect a HQ of 0.1. Table 2-2 located in the current version of the Alabama Risk-Based Corrective Action (ARBCA) document reflects the appropriate HQ and may be used to minimize any errors made when utilizing the soil PSVs.

4.3.5 **Sediment -** PSVs for constituents in sediment shall be based on whether human health or ecological health is the major concern. If ecological concerns are deemed to predominate, see section 4.3.6. If human health is the prevailing concern, then the human health PSVs for sediment shall be consistent with those for soils.

4.3.6 **Ecological** – Surface water and sediment data collected should be compared to the USEPA Region 4 Ecological Screening Values with respect to ecological receptors. Additionally, sediment that is not saturated year round should be evaluated as surficial soil. In the absence of a Region 4 Ecological Screening Value for surface water, the surface water concentrations should be compared to the Water Quality Criteria located in ADEM Admin. Code 335-6-10 (the "Consumption Fish/Water" pathway should be used). If the surface water is a "water of the state" as defined in ADEM Admin. Code R. 335-6-10-.02(10), the surface water concentrations should be compared to the Water Quality Criteria regardless of whether a Region 4 Value exists, and the ADEM Water Division should be contacted. In the absence of a USEPA Region 4 Ecological Screening Value or an ADEM Water Quality Criteria Value, surface water should be compared to a groundwater value (see Section 4.3) and the sediment should be compared to a soil value (see Table 2-2).

4.4 Evaluation of Background Conditions

While PSVs provide a general and rapid assessment of risk, many PSVs, particularly for inorganic constituents, may be substantially less than concentrations that are found in environmental media under ambient conditions. Site managers should consider background conditions during site characterization.

To determine if a natural background is present in the soils, a minimum of four background samples should be obtained in an area which is reasonably expected to be unaffected by current or historical processes, but within depositional environments similar to those in impacted areas. Two times the arithmetic mean of the background sample's concentrations should be screened against the on-site maximum detected concentration. If the contaminant of potential concern is less than 2 times the background level, then the contaminant should be eliminated as a concern.

For groundwater, up-gradient monitoring wells should be installed in order to provide a measure of ambient groundwater quality, and an indication of up-gradient sources of contamination. The statistical procedures used to evaluate the groundwater samples are site-specific due to the variability of groundwater flow parameters throughout the state.

In some cases, it may be necessary to evaluate an anthropogenic background source. Anthropogenic substances are natural and human-made substances present in the environment as a result of human activities (not specifically related to the site in question). Some chemicals may be present in background as a result of both natural and man-made conditions (such as naturally occurring arsenic and arsenic from pesticide applications or smelting operations).

Generally, the type of background substance (natural or anthropogenic) does not influence the statistical or technical method used to characterize background concentrations. For this reason, the anthropogenic background concentration should be determined in the same manner as described above for the natural occurring background concentrations.

For other media or additional information concerning the determination of a background concentration, please contact the Department.

4.5 Comprehensive Risk Evaluation

If maximum detected site concentrations exceed background conditions and PSVs, a more comprehensive evaluation of risks to human health or the environment may be needed. The most recent edition of the ARBCA guidance document should be utilized when a more comprehensive evaluation is determined necessary.

4.6 Risk Management Evaluation

In order to maximize the conservation of our precious State resources, ADEM encourages sites to develop PSVs and remediation levels based on an unrestricted land use (residential) scenario. PSVs and remediation levels based on an alternate land use scenario (e.g.: industrial) may be appropriate if the site owner/operator is willing to establish an appropriate combination of engineering and land-use controls to ensure against inappropriate uses of the property. Such controls may require some form of enforceable document issued by the State (e.g.: a permit, or a consent agreement) to ensure long-term maintenance of these controls, if necessary, and depending on the specific regulatory program involved.

5.0 REMEDIATION

5.1 Section Outline

5.2 Purpose

The purpose of this section is to outline specific activities that are necessary for sites that have been determined to be a threat to human health and the environment, and/or where elevated plumes and/or areas of contamination exceeding regulatory limits have been determined.

5.3 Necessary Elements

5.3.1 Remediation Levels – A summary of the remediation goals should be provided that includes acceptable risk-based target levels that apply to the site (see Section 4 of this document).

5.3.2 Plans/Designs - [illegible]emediation plan should be submitted to the Department for review prior to implementation in accordance with applicable requirements. Cleanup/remediation plans should include, but not be limited to, the following:

(a) A description of the cleanup objectives with discussions of the remediation technology (or technologies) to be applied at the site for the contaminants of concern in all affected media.

(b) If free phase product is present, and extraction is the method for remediation, a description of the technique and placement of the extraction point(s) or a description of existing extraction is appropriate when applicable.

(c) Detailed plans and an engineering report with a description of the proposed cleanup method to remediate soils, sediments, and groundwater, and to mitigate potential hazardous discharges into a surface water source.

(d) A detailed description of the proposed groundwater remediation system including plans describing sampling points, monitoring well locations, analytical methods, and any other procedures or systems used for evaluating the effectiveness of the remediation plan, if applicable.

(e) A detailed description of how all treated wastewater or soils removed will be handled.

(f) The institutional requirements such as State or local permit requirements, or other environmental or public health requirements that may substantially affect implementation of the remediation system.

(g) An itemized schedule for implementation of the cleanup plan.

(h) A site plan map showing:

  i. A North directional arrow,

  ii. A horizontal scale,

  iii. Culture relevant to the site (buildings, structures, etc.)

  iv. The location of the point source of the contaminant release,

  v. All sumps, above ground storage tanks, pipelines, etc.,

  vi. The horizontal and vertical extent of free-product and/or dissolved phase contaminants in groundwater to above the regulatory levels,

  vii. The horizontal and vertical extent of the soils and/or sediments that are contaminated at levels in exceedance of the PSVs.

  viii. The location of the groundwater monitoring well system, which defines the horizontal and vertical extent of contamination,

  ix. The location of the proposed remediation system extraction/injection wells or points, and

  x. The proposed locations of an adequate number of wells to monitor the effectiveness of the remediation system.

(i) A potentiometric surface map contoured to equal mean sea level elevations of the static water level taken during the same measuring event in all groundwater monitoring wells and/or piezometers at the site. The potentiometric surface map should include:

  i. A North directional arrow,

  ii. A horizontal scale,

iii. The direction of groundwater flow indicated by arrows pointing down-gradient and perpendicular to the contours of equal groundwater elevation.

iv. Groundwater elevations for the event in each well.

(j) The format of the remediation plan effectiveness report will vary depending on the type of remediation technology utilized and the program under which the site is operating. The report should be prepared in accordance with applicable program requirements. The general report format should include, at a minimum, the following:

i. A detailed description of all remediation and/or groundwater sampling activities,

ii. A detailed description including summary tables of all analysis collected and conclusions developed,

iii. A site map showing the location of the groundwater monitoring system (if groundwater is being remediated),

iv. Potentiometric surface maps for all applicable aquifers or separate saturated zones being monitored (if groundwater is being remediated),

v. Time vs. Concentration graphs of selected wells and parameters to demonstrate the effectiveness of the groundwater remediation system (if groundwater is being remediated),

vi. Capture zone modeling results indicating the area of influence, and

vii. Recommendations for upgrade, modification of the system, or any additional remediation activities.

5.3.3 Decontamination - Prior to utilization of sampling equipment, all equipment should be properly decontaminated in accordance with Appendix E. All personnel should wear clean disposable sampling gloves when obtaining or handling samples. Gloves should be changed between each sampling event.

5.3.4 Case Studies on New Technologies - For new remediation technologies that are not currently discussed in Appendix F of this document, or have not been previously utilized in the State of Alabama, an effectiveness report or case study report developed from other sites utilizing the proposed remediation system should be submitted. The report should demonstrate the effectiveness of the proposed remediation system and comparable environmental conditions.

5.3.5 Management of Remediation Waste (All Media)

Remediation of sites under various corrective action programs may involve the management of large amounts of waste such as contaminated soils, recovered groundwater, debris, and sludges. All remediation wastes generated during site activities should be managed as IDW and in accordance with Appendix D and the ADEM regulations. There may be special management options for on site generated remediation wastes. Site managers should consult ADEM for the appropriate requirements.

5.3.6 Regulatory Requirements (SID, NPDES, UIC, Air, UST, etc.)

Many remediation technologies may be subject to special regulatory and/or permitting requirements, including, but not limited to:

(a) National Pollutant Discharge Elimination System (NPDES) permitting (ADEM Water & Field Operations Divisions);

(b) State Indirect Discharge (SID) permitting (ADEM Water & Field Operations Divisions);

(c) Underground Injection Control (UIC) permitting (ADEM Water Division);

(d) Source Water Assessment Program (ADEM Water Division); and

(e) Air Emissions (Air Division).

Site managers should consult with ADEM for any specific regulatory requirements associated with the proposed remediation technology.

5.4 Remedy Selection

5.4.1 Source Control - Source control measures should be evaluated as part of the remedy decision process at all sites particularly where MNA is under consideration as the remedy or as a remedy component. Source control measures include removal, treatment, or containment, or a combination of these approaches.

Contaminant sources that are not adequately addressed complicate the long-term cleanup effort. For example, following free product recovery, residual contamination from a petroleum fuel release may continue to leach significant quantities of contaminants into the groundwater posing unacceptable risks to humans and/or the environment. Such a lingering source often extends the time necessary to reach remediation objectives. This leaching can occur even while contaminants are being naturally attenuated in other parts of the plume. If the rate of attenuation is lower than the rate of replenishment of contaminants to the groundwater, the plume can continue to expand thus contaminating additional groundwater and potentially posing a threat to down-gradient receptors.

Control of source materials is the most effective means of ensuring the timely attainment of remediation objectives. The Department, therefore, expects that source control measures will be taken at most sites where practicable. At many sites it will be appropriate to implement source control measures during the initial stages of site remediation (“phased remedial approach”), while collecting additional data to determine the most appropriate remedy. See Appendix F for more information on possible remedial technologies.

5.5 Land-Use Controls

5.5.1 During the initial phase of cleanup, the site manager should:

(a) Establish clear objectives (what are you trying to accomplish through the use of land-use controls (LUCs)?);

(b) Discuss future land use plans with the community and local government to assist in analyzing the appropriate LUCs and other remedial alternatives;

(c) Evaluate LUCs using the appropriate threshold, balancing, and modifying criteria; and,

(d) Coordinate with regional attorneys on legal matters and the State as appropriate.

5.5.2 During remedy selection, the site manager should:

(a) Present information that aids the public to understand the impacts of the specific LUCs and their relationship with the overall remedy;

(b) Clearly describe the objectives to be attained by LUCs;

(c) Specify performance standards (e.g.: prevent exposure to contaminated groundwater by prohibiting well drilling);

(c) Consider layering LUCs to enhance their overall effectiveness;

(e) Discussions with entities (e.g.: local/state governments) involved in implementing LUCs;

(f) Discuss the kinds of controls envisioned and include enough information to show that effective implementation of the LUCs can reasonably be expected;

(g) Discuss plans for monitoring land use and other aspects of the remedy that depend on LUCs;

(h) Discuss the enforcement mechanisms that are anticipated to ensure the long-term reliability of the LUCs (e.g.: notice to the deed to the property); and,

(i) Continue coordination with attorneys.

5.5.3 During remedy implementation, the site manager should ensure that appropriate measures are taken to implement the LUCs (e.g.: arrange discussions between PRPs, other property owners, and local government or state officials);

5.5.4 During Post-Remediation activities (e.g.: a CERCLA 5-year review), the site manager should:

(a) Evaluate both the administrative/legal components as well as the physical evidence to ensure that LUCs are both implemented and fully effective;

(b) Ensure that any LUCs are available for inspection by any person performing a standard title search on the property and that the objectives of the LUCs are clearly presented; and

(c) Ensure that the site is listed on the Alabama Contaminated Properties Inventory List.

Appendix A

Glossary

APPENDIX A GLOSSARY

ADEM - The Alabama Department of Environmental Management as established by Code of Alabama 1975, § 22-22A-4.

Administrator - The Administrator of the United States Environmental Protection Agency.

ADPH - The Alabama Department of Public Health.

AHWMMA - The Alabama Hazardous Wastes Management and Minimization Act of 1978, as amended, Code of Alabama 1975, §§ 22-30-1 et seq.

ASTM - American Society for Testing and Materials. A technical society with headquarters located at 1916 Race Street, Philadelphia, Pennsylvania, 19103, which publishes national standards for the testing and quality assurance of materials.

CERCLA - The Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended.

Certification - A statement of professional opinion based upon knowledge and belief.

CFR - Code of Federal Regulations.

Commission - The Alabama Environmental Management Commission as established by Code of Alabama 1975, § 22-22A-6.

Contaminant - "Contaminant" means any man-made or man-induced alteration of the chemical, physical or biological integrity of soils, sediments, air, surface water or groundwater including, but not limited to, such alterations caused by any:

1. Hazardous substance (as defined in the Comprehensive Environmental Response, Compensation and Liability Act, 42 USC § 9601(14));
2. Hazardous waste (as defined in ADEM Administrative Code 335-14);
3. Hazardous constituent (as defined in ADEM Administrative Code 335-14-2-Appendix VIII and/or ADEM Administrative Code 335-14-5-Appendix IX);
4. Solid waste (as defined in ADEM Administrative Code 335-13); or,
5. Petroleum product.

COPC – Constituent of Potential Concern

Director - The Director of ADEM, appointed pursuant to Code of Alabama 1975, § 22-22A-4, or his designee.

Disposal - The discharge, deposit, injection, dumping, spilling, leaking, or placing of any hazardous waste into or on any land or water so that such hazardous waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters including groundwater.

Endangered or Threatened Species – Any species listed as such pursuant to Section 4 of the Endangered Species Act.

Engineer - A person registered as a professional engineer with the State of Alabama Board of Registration for Professional Engineers and Land Surveyors and practicing under the Rules of Professional Conduct, specifically Canon II.

EPA - The United States Environmental Protection Agency.

Geologist - A person who holds a license as a professional geologist under the Alabama Professional Geologist Licensing Act.

GPS Method – Method for the determination of latitude and longitude at a point using Global Positioning System (GPS), collected and differentially corrected data to an EPA accepted accuracy of 25 meters at a specified datum (*i.e.,* NAD 83).

Global Positioning System (GPS) - The location of items on the earth's surface by determining their coordinates in relation to a series of satellites.

Land-Use Controls (LUCs) – LUCs are non-engineered controls instruments such as administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use.

Land Surveyor - A person registered as a Land Surveyor with the State of Alabama Board of Registration for Professional Engineers and Surveyors and practicing under the Rules of Professional Conduct (Code of Ethics).

National Pollutant Discharge Elimination System (NPDES) - The national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits for the discharge of pollutants into waters of the state.

Person - Any and all persons, natural or artificial, including, but not limited to, any individual, partnership, association, society, joint stock company, firm, company, corporation, institution, trust, other legal entity, business organization or any governmental entity and any successor, representative, responsible corporate officer, agent or agency of the foregoing.

RCRA - The Federal Resource Conservation and Recovery Act of 1976, as amended, (42 U.S.C. §§ 6901 et seq.).

Regional Administrator - The Regional Administrator for the EPA Region in which the facility is located, or his designee.

Regulated Substance - Any substance defined in section 101(14) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 (but not including any substance regulated as a hazardous waste under Division 14 of the ADEM Administrative Code); and petroleum, including crude oil or any fraction thereof that is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute). The term "regulated substance" includes, but is not limited to, petroleum and petroleum-based substances comprised of a complex blend of hydrocarbons derived from crude oil through processes of separation, conversion, upgrading, and finishing, such as motor fuels, jet fuels, distillate fuel oils, residual fuel oils, lubricants, petroleum solvents, and used oils.

Remediation waste - All solid and hazardous wastes, and all media (including groundwater, surface water, soils, and sediments) and debris that contain listed hazardous wastes or that themselves exhibit a hazardous characteristic and are managed for implementing cleanup.

SARA - The Superfund Amendments and Reauthorization Act of 1986.

Solid waste - means a waste as defined by ADEM Admin. Code R. 335-14-2-.01(2).

Spill - An unplanned, accidental, or unpermitted discharge, deposit, injection, leaking, pumping, pouring, emitting, dumping, placing, or releasing of hazardous wastes, or materials which when spilled become hazardous wastes, into or on the land, the air, or the water.

State Health Officer - The Health Officer for the State of Alabama as set out in § 22-2-8, Code of Alabama 1975, or his designee provided by law.

Appendix B

Monitoring Well Installation/Development/Abandonment Guidelines

APPENDIX B - MONITORING WELL INSTALLATION/DEVELOPMENT/ABANDONMENT GUIDELINES

B.1. Appendix Outline

B.2. Monitoring Well Drilling Methods

The following are commonly utilized drilling methods that should be considered when plans are being made to install a permanent monitoring well. The final drilling method selection should be based on site-specific conditions.

B.2.1 Hollow-Stem Auger - This type of auger consists of a hollow, steel stem or shaft with continuous, spiraled steel flight, welded onto the exterior side of the stem, connected to an auger bit and when rotated transports cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring well can be installed inside of the hollow-stem augers with little or no concern for the caving of soils and/or water table.

B.2.2 Solid-Stem Auger - This type of auger consists of a solid stem or shaft with a continuous spiraled steel flight, welded on the outer side of the stem, connected to an auger bit and when rotated transports cuttings to the surface. This auger method is used in cohesive and semi-cohesive soils that do not have a tendency to collapse when disturbed.

B.2.3 Rotary Method - This method consists of a drill pipe or drill stem coupled to a drilling bit that rotates and cuts through the soils. The cuttings produced from the rotation of the drilling bit are transported to the surface by drilling fluids, which generally consists of water, drilling mud, or air. The water, drilling mud, or air are forced down through the drill pipe, and out through the bottom of the drilling bit. The cuttings are then lifted to the surface between the borehole wall and the drill pipe. The type of rotary method used is dependent upon site-specific conditions and the information desired for the investigation (e.g.: the mud rotary method provides good information on soil strength properties).

B.2.4 Rotosonic Drilling – This method combines high frequency vibrations, downward pressure, and relatively slow rotations to advance a dual string of drill pipe. This combination of forces advances the drill pipe through soil and rock without the use of drilling fluids. The dual string of drill pipe is used to sample and advance the hole and consists of an inner core barrel sampler and an outer pipe casing. The core barrel is driven ahead of the outer casing and is used to collect a representative continuous core sample. Once the core barrel is driven to the required depth, the outer casing is then driven down over the core barrel. The outer casing prevents the hole from collapsing when the core barrel is extracted for sample retrieval. Drilling can be completed without the use of fluids, but water is commonly used during the driving of the outer casing to flush material from the annual space between the core barrel and the pipe casing.

B.2.5 Other Methods - Other methods such as the cable-tool method, the jetting method, the boring (bucket auger) method, and direct push technologies (e.g.: GeoProbe®) are available. If these and/or other methods are proposed for installing monitoring wells, specific details with respect to the equipment and drilling fluids that will be used, and the activities that will be performed should be included in the work plan. Prior approval by the Department will also be required before initiation of the proposed monitoring well installation activities.

B.3. Monitoring Well Construction Methods

B.3.1 Type-I/Temporary Monitoring Wells or Piezometers - A temporary monitoring well is any well that is used for the establishment of groundwater flow conditions, the delineation of contaminant plumes at a point in time, and for some site screening purposes. They are not intended to replace permanent monitoring wells. Perhaps the best use for temporary wells is in conjunction with a mobile laboratory , where quick analytical results can be used to delineate contaminant plumes. Temporary monitoring wells locations are not permanently marked, nor are their elevations normally determined. Sand pack materials may or may not be used but typically there is no bentonite seal, grout surface completion, or extensive development (as normally applies to permanent monitoring wells). Temporary wells are generally installed, purged, sampled, removed and backfilled in a matter of hours. Temporary wells may be left overnight for sampling the following day, but the well must be secured if the well is not sampled immediately after construction.

The materials used in construction of temporary monitoring wells or piezometers are the same standard materials used in the construction of permanent monitoring wells. Sand used for the filter pack (if any) should be as specified in Section 6.6.3 of USEPA Region IV's Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (latest edition).

There are six types of temporary monitoring well installation techniques that have been demonstrated as acceptable. The type selected for a particular site is dependent upon the conditions. The project leader and site geologist should be prepared to test temporary well installations on site and select the best solution. Temporary wells are cost effective, may be installed quickly, and provide a synoptic picture of groundwater quality. These include:

(a) No Filter Pack – After the borehole is completed, the casing and screen are simply inserted. This type is extremely sensitive to turbidity fluctuations, because there is no filter pack. This is the most inexpensive and fastest well to install.

(b) Inner Filter Pack – This type differs from the "No Pack" only in that a filter pack is placed inside the screen to a level approximately 6 inches above the well screen. This ensures that all water within the casing has passed through the filter pack. For this type well to function properly, the static water level must be 6-12 inches above the filter pack.

(c) Traditional Filter Pack – The screen and casing is inserted into the borehole. Sand is poured into the annular space surrounding the screen and casing. The well should then be developed to establish in situ aquifer or saturated conditions.

(d) Double Filter Pack – the borehole is advanced to the desired depth. As with the "inner filter pack" the well screen is filled with filter pack material and the well screen and casing inserted until the tip of the filter pack is at least 6 inches below the water table. Filter pack material is poured into the annular space around the well screen. This type temporary well construction is very effective in aquifer where fine silts or clays predominate.

(e) Well-in-a-Well – The borehole is advanced to the desired depth. At this point, a 1-inch well screen and sufficient riser is inserted into a 2-inch well screen with sufficient riser, and centered. Filter pack material is then placed into the annular space surround the 1-inche well screen, to approximately 6 inches above the well screen. The well is then inserted into the borehole.

(f) Temporary Well Installation using the Geoprobe® Screen Point 15 Groundwater Sampler – The Geoprobe® Screen Point 15 Groundwater Sampler is a discrete interval groundwater sampling device that can be pushed to pre-selected sampling depths in saturated, unconsolidated materials, opened and sampled as a temporary well. It is a selled sample device, opened at the desired depth, yielding a representative, uncompromised sample from that depth. Using knock-out plugs, this method also allows for grouting of the push hole during sample tool retrieval after sample collection.

For additional information refer to the USEPA Region IV's Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (latest edition) section 6.10.

B.3.2 Permanent Type-II Monitoring Wells

(a) The borehole should be bored, drilled, or augered as close to vertical as possible, and checked with a plumb bob or level. Slanted boreholes will not be appropriate unless specified in the design.

(b) The well casings should be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed by the use of centralizers and/or a plumb bob and level. Another method of placing the well screen and casing into the borehole and plumbing it at the same time is to suspend the string of well screen and casings in the borehole by means of the wire-line on the drill rig. Teflon tape can be used to wrap the threads to insure a tight fit and minimize leakage.

(c) Before placing the well screen and casing on to the bottom of the borehole, at least 6 inches of filter material should be placed at the bottom of the borehole to serve as a firm footing.

(d) The string of well screen and casings should then be placed into the borehole and plumbed. Centralizers can be used to plumb a well but should be placed below the well screen and above the bentonite pellet seal.

(e) All permanent wells should have a maximum screened interval of 10 feet, a minimum inside diameter of 2 inches and should be constructed of materials that are based on the geologic conditions and resistant to leaching and deterioration from the COPCs. There are some exceptions that are allowed but must be approved by the Department on a case-by-case basis. Permanent wells installed utilizing direct push technologies is program dependent and determined site-specifically. A plan should be submitted to the Department and approved prior to any small diameter permanent well installation.

(f) When placing the well screen and casing through hollow stem augers, the augers should be slowly extracted as the filter pack, bentonite seal, and grout are tremied into place. After the string of well screen and casing is plumbed in the open borehole, the filter material should then be placed around the well screen, by tremie method, to a minimum of 2 feet above the top of the well screen.

(g) A bentonite seal should then be tremied onto the filter pack to a minimum thickness of 2 feet. The bentonite seal should then be allowed to hydrate for a minimum of 8 hours or the manufacturer's recommended hydration time, whichever is longer.

(h) After hydration of the bentonite seal has been completed, the grout (bentonite/grout mixture) should be pumped by the tremie method into the annular space around the casing up to within 2-feet of the ground surface or below the frost line, whichever is greater. The grout should be allowed to set for a minimum of 24 hours before the surface pad and protective casing are installed.

(i) A protective casing with a locking cap should be installed around the monitoring well, with concrete or neat cement surface pad installed around the monitoring well and the protective casing. The surface pad should have the dimensions of 2 feet by 2 feet square, and an approximate thickness of 6 inches (4 inches above the ground surface). The surface pad should be angled such that water flows away from the monitoring well.

(j) Bumper guards should be placed around the concrete surface pad in a configuration that provides maximum protection to the well. The bumper guards should extend above the ground surface at a minimum of 3 feet and have a total minimum length of 5 feet.

(k) If the monitoring wells are installed in a high traffic area, the monitoring wells may be finished to the ground surface and installed with watertight flush-mounted traffic and/or manhole covers. The flush-mounted covers should be installed as far above grade as practical to minimize standing water and promote runoff.

(l) All monitoring wells should include a padlock or specialized locks and should be permanently marked with the well number, date installed, site name, top-of-casing elevation and ground elevation.

B.3.3 Permanent Type-III (Double-Cased) Monitoring Wells

(a) Type-III or double cased monitoring wells should be constructed when there is a reason to believe that interconnection of the two aquifers by well construction may cause cross contamination, and/or when flowing sands make it impossible to install a monitoring well using conventional methods.

(b) A pilot borehole should be drilled through the overburden and/or the contaminated zone into a confining clay layer, to bedrock, or through the first saturated zone. The borehole should be extended into the clay, bedrock or unsaturated zone underlying the initial saturated zone at a minimum of 2 feet, if possible (1 foot into bedrock is adequate). The final depth should be approved by a senior field geologist.

(c) An outer casing should be placed into the borehole and sealed with grout. The size of the outer casing should be of sufficient inside diameter to contain the inner casing, and the 2-inch minimum annular space.

(d) The outer casing should be grouted by the tremie method from the bottom to within 2 feet of the ground surface. The grout should be pumped into the annular space between the outer casing and the borehole wall. A minimum of 24 hours should be allowed for the grout plug (seal) to cure before attempting to drill through it. The grout mixture used to seal the outer annular space should be neat cement,

cement/bentonite, cement/sand, or a 30% solids bentonite grout. However, the seal or plug at the bottom of the borehole and outer casing should consist of a Type-I Portland cement/bentonite or cement/sand mixture. The use of pure bentonite grout for a bottom plug or seal is not appropriate. After the grout plug has been allowed to cure, the boring for the inner casing should be advanced to the next saturated zone or aquifer, followed by the installation of a permanent monitoring well. When drilling through the seal, care should be taken to avoid cracking, shattering, and/or washing out the seal. Removal of the outer casing after the well screens and casings have been installed and grouted is not appropriate.

(e) During the investigation to determine the vertical extent of contamination, it may require additional outer casings to be installed (telescoping methods). Each outer casing should be installed in accordance with the above guidance.

B.3.4 Permanent Bedrock Wells

(a) The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock (1-foot minimum).

(b) An outer casing is then installed into the borehole by setting it into the bedrock, and grouting it into place as described in the previous sections.

(c) After the grout has been allowed to set (minimum of 24 hours), the borehole should be advanced through the grout seal or plug into a water producing zone in the bedrock by rock coring methods.

(d) An inner casing and well screen with a filter pack, bentonite seal and annular grout should then be installed.

(e) The well is completed with a surface protective casing and concrete pad.

B.3.5 Nested or Cluster Wells

(a) Nested or Cluster Wells are two or more wells that are screened at different elevations in a single aquifer or multiple aquifers and typically installed within 5 feet of each well.

(b) Nested or Cluster Wells typically consist of one Type-II well and one or more Type-III well(s) (See above construction requirements for Type-II and Type-III wells).

B.4. Monitoring Well Development Methods

The main purpose of developing new monitoring wells is to remove the residual materials remaining in the wells after installation has been completed and to try to re-establish the natural hydraulic flow conditions of the formations that may have been disturbed by the well construction activities.

B.4.1 Time Period - A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed.

B.4.2 Development - A new monitoring well should be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In some cases, this may require continuous flushing or development activities over a period of several days.

B.4.3 Methods - Well development can be performed by the following methods. The methods listed below can be used individually or in combination. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a well. Wells developed with stressful measures may require as long as a 7-day interval before sampling. In particular, air surge developed wells require 48 hours or longer after development so that the formation can dispel the compressed air and restabilize to pre-well construction conditions.

(a) Over-pumping – Over-pumping is the most commonly employed well development technique. A pump is installed into a well and pumping is initiated to induce groundwater flow towards the well. Fine particulate material that moves into the well is discharged by the pump. In over-pumping, the pump is operated at a capacity that substantially exceeds the ability of the formation to deliver water. This flow velocity into the well usually exceeds the flow velocity that will subsequently be induced during the sampling process. The increased velocity causes rapid and effective migration of particulates toward the pumping well and enhances the development process. Proper design is needed to avoid well collapse, especially in deep wells. The USEPA recognizes over-pumping as an effective development method if flow reversal or surging activities are also conducted to avoid the occurrence of bridging in the well pack. When monitoring well installations are to be made in formations that have low hydraulic conductivity, this well development method will be unsatisfactory.

(b) Backwashing - A pump is installed into a well and pumping is initiated to induce groundwater flow towards the well. Fine particulate material that moves into the well is discharged by the pump. Where there is no backflow prevention valve installed, the pump is alternately started and stopped. This starting and stopping process allows the column of water that is initially picked up by the pump to be alternately dropped and raised up in a surging action. Each time the water column falls back into the well, an outward surge of water flows into the formation. This surge tends to loosen the bridging of the fine particles so that the upward motion of the column of water can move the particles into and out of the well. In this manner, the well can be pumped, over-pumped and back-flushed alternately until such time as satisfactory development has been attained. When monitoring well installations are to be made in formations that have low hydraulic conductivity, this well development method will be unsatisfactory.

(c) Surge Block - Surge blocks can be used effectively to destroy bridging and to create the agitation that is necessary to develop a well. A surge block is used alternately with either a bailer or pump so that material that has been agitated and loosened by the surging action is removed. The cycle of surging-pumping/bailing is repeated until satisfactory development has been attained. The surge block is lowered to the top of the well intake and then operated in a pumping action with a typical stroke of approximately 3 feet. The surging is usually initiated at the top of the well intake and gradually is worked downward through the screened interval. The surge block is removed at regular intervals and the fine material that has been loosened is removed by bailing and/or pumping. Surging begins at the top of the well intake so that sand or silt loosened by the initial surging action cannot cascade down on top of the surge block and prevent removal of the surge block from the well. Surging is initially gentle and the energy of the action is gradually increased during the development process.

(d) Bailer - In relatively clean, permeable formations where water flows freely into the borehole, bailing is an effective development technique. The bailer is allowed to fall freely through the borehole until it strikes the surface of the water. The contact of the bailer produces a strong outward surge of water that is forced from the borehole through the well intake and into the formation. This tends to break up bridging that has developed within the formation. As the bailer fills and is rapidly withdrawn, the drawdown created in the borehole causes the particulate matter outside the well intake to flow through the well intake and into the well. Subsequently bailing removes the particulate matter from the well. To enhance the removal of the sand and other particulate matter from the well, the bailer can be agitated by rapid short strokes near the bottom of the well. This agitation makes it possible to bail the particulates from the well by suspending or slurrying the particulate matter. Bailing should continue until the water is free from suspended particulate matter and until stabilization of all field parameters (pH, specific conductivity, temperature, and turbidity) is achieved.

(e) Airlift Pumping - Air lifting, without exposing the formations being developed directly to air, can be accomplished by properly implemented pumping. To do this, the double pipe method of air lifting is preferred. The bottom of the airlift should be lowered to within no more than 10 feet from the top of the well intake and in no event should the airlift be used within the well intake. If the airlift is used to surge the well, by alternating the air on and off, there will be mixing of aerated water with the water in the well. Therefore, if the well is to be pumped by airlifting, the action should be one of continuous, regulated discharge. This can be effectively accomplished only in relatively permeable aquifers. The introduction of air into the aquifer, such as conducting air surging activities, is not appropriate. When monitoring well installations are to be made in formations that have low hydraulic conductivity, this well development method will be unsatisfactory.

B.4.4 Completion - The onsite geologist should make the decision as to the development completion of each well. All field decisions should be documented in the field logbook.

B.5. Well Abandonment Procedures

The objectives of the abandonment procedure are to: 1) eliminate physical hazards; 2) prevent groundwater contamination; 3) conserve aquifer yield and hydrostatic head; and 4) prevent intermixing of desirable and undesirable waters.

The Department requires that all test holes, including test wells, partially completed wells, and completed wells be properly plugged and abandoned upon completion of either the site investigation phase or remediation phase. The purpose of sealing an abandoned boring or monitoring well is to prevent any further disturbance to the pre-existing hydrogeologic conditions in the subsurface. No materials that could impart taste, odor or toxic compounds to water may be used in the sealing process. The guiding principle to be followed by the contractor in the sealing of abandoned wells is the restoration, as far as feasible, of the controlling geological conditions that existed before the well was drilled or constructed.

B.5.1 Soil Borings - Soil borings should be abandoned in accordance with the following:

(a) A boring should be measured for depth before it is sealed to ensure freedom from obstructions that may interfere with effective sealing operations.

(b) All borings should be sealed by backfilling with concrete, grout, neat cement or a grout/cement mixture.

(c) All backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method).

(d) The top 2 feet of the borehole should be poured with concrete to ensure a surface seal (plug).

ADEM will review alternative soil boring abandonment proposals on a site-by-site basis. All alternative soil boring abandonment proposals should be approved by ADEM prior to implementation.

B.5.2 Monitoring Wells - Regulatory requirements and accepted procedures for the abandonment of monitoring wells, public water supply wells and domestic water wells vary depending upon the regulatory program. The appropriate subsections listed below should be consulted prior to developing a well abandonment plan. To view an acceptable outline for a well abandonment plan, see Attachment 1 of Appendix B.

(a) Solid Waste Program Sites

The requirements for monitoring well abandonment at facilities permitted under the Solid Waste Regulations, 335-13, include the following:

i. The owner or operator should notify the Department that the design, installation, development, and/or abandonment of any monitoring wells, piezometers and other measurement, sampling, and analytical devices have been documented, and placed in the operating record.

ii. The monitoring wells, piezometers, and other measurement, sampling, and analytical devices should be operated and maintained so that they perform to design specifications throughout the life of the monitoring program.

iii. Abandoned wells and boreholes should be abandoned in accordance with the procedures outlined in this document in order to prevent contamination of groundwater resources. A plan of abandonment should be submitted and approved by the Department prior to implementing abandonment of any well.

iv. A well should be measured for depth prior to sealing to ensure that it is free from any obstructions that may interfere with sealing operation.

v. Where feasible, wells should be completely filled with neat cement. If the well cannot be completely filled, the sealing material for the top 20 feet should be neat cement and no material that could impart taste, odor, or toxic components to water may be used in the sealing process.

vi. The casing should be removed from each well in order to ensure placement of an effective seal. If the casing cannot be readily removed, it should be perforated to ensure that proper sealing is obtained.

vii. Concrete, cement grout, or neat cement should be used as primary sealing materials and should be placed from the bottom upwards using methods that will avoid segregation or dilution of material.

viii. Complete, accurate records of the abandonment procedure should be kept for each well abandoned. The record of abandonment should include, at a minimum, the depth of each layer of all sealing and backfill material, the quantity of sealing materials used, measurements of static water levels and depths, and any changes made in the well during the plugging or sealing, such as perforating casing. A copy of these records should be submitted to the Department and a copy placed in the operating record.

(b) Public Water Supply Wells

Public water supply wells should be abandoned only after consultation with the ADEM Water Supply Branch. ADEM Admin. Code R. 335-7-5-.16 states that abandoned wells, partially completed wells, and boreholes should be filled and sealed to prevent contamination of groundwater formations. Where feasible, or when required by the Department, wells should be completely filled with neat cement. Other wells should be sealed in accordance with American Water Works Association (AWWA) Standard A100 Section 13 as outlined in the following:

American Water Works Association Standards A100-(latest edition)

Section 13.1 General

Abandoned test holes, including test wells, partially completed wells, and completed wells, should be sealed.

Section 13.1.1 Need for sealing wells

Wells need to be sealed for the following reasons:

- To eliminate physical hazards,
- To prevent contamination of groundwater,
- To conserve yield and hydrostatic head of aquifer, and
- To prevent intermingling of desirable and undesirable waters.

Section 13.1.2 Restoration of geological conditions

The guiding principle to be followed by the contractor in the sealing of abandoned wells is the restoration, as far as feasible, of the controlling geological conditions that existed before the well was drilled or constructed.

Section 13.2 Sealing requirements

A well should be measured for depth before it is sealed to ensure freedom from obstructions that may interfere with effective sealing operations.

Section 13.2.1 Casing removal

Removal of casing from some wells may be necessary to ensure placement of an effective seal.

Section 13.2.2 Exception to removing casing

If the casing cannot be readily removed, it should be perforated to ensure the proper sealing required.

Section 13.2.3 Sealing materials and placement

Concrete, cement grout, sealing clay or neat cement should be used as primary sealing materials and should be placed from the bottom upward by methods that will avoid segregation or dilution of material.

Section 13.3 Records of Abandonment Procedures

Complete, accurate records should be kept of the entire abandonment procedure to provide detailed records for possible future reference and to demonstrate to the governing state or local agency that the hole was properly sealed.

Section 13.3.1 Depths sealed

The depth of each layer of all sealing and backfilling materials should be recorded.

Section 13.3.2 Quantity of sealing material used

The quantity of sealing materials used should be recorded. Measurements of static water levels and depths should be recorded.

Section 13.3.3 Changes recorded.

Any changes in the well made during the plugging or sealing, such as perforating casing, should be recorded in detail.

(c) Hazardous Waste Management Sites

i. The ADEM Hazardous Waste Program considers improperly abandoned monitoring wells to be a serious concern. Any boreholes or monitoring wells that are improperly constructed or unused should be properly abandoned after the proper approval has been received from ADEM.

ii. Experienced geologists, geotechnical engineers and drillers should be consulted prior to abandonment.

iii. If the well to be abandoned is contaminated, the safe removal and proper disposal of the well materials should be ensured by the owner/operator.

iv. Appropriate measures should be taken to protect the health and safety of individuals when abandoning a well or borehole.

v. The monitoring well or borehole should be sealed so that it can not act as a conduit for the migration of contaminants from the ground surface to the water table or between aquifers.

vi. The preferred method should be to completely remove the well casing and screen from the borehole. This may be accomplished by augering with a hollow stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing can then be removed from the hole with the drill rig or other appropriate equipment. If it is determined that the well casing cannot be removed, approval should be sought from the Department to perforate the casing to ensure that a proper seal is obtained when backfilling and leave the casing in place. Approval will be granted on a site-by-site basis and is dependent upon the unique conditions that may exist at a site preventing the removal of the casing.

vii. The clean borehole can then be backfilled with the appropriate grout material (e.g.: concrete, bentonite grout, or neat cement). The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method).

viii. The top 2 feet of the borehole should be poured with concrete to ensure a secure surface seal (plug). If the area has very heavy traffic use, and/or the well locations need to be permanently marked, then a protective surface pad and/or steel bumper guards should be installed. The concrete surface plug can also be recessed below ground surface if the potential for construction activities exists.

ix. Because of its brittleness, PVC wells may be more difficult to remove than metal casing wells. If the PVC well casing breaks during removal, the borehole should be cleaned out by using a drag bit or roller cone bit with the wet rotary method to grind the casing into small cuttings that will be flushed out of the borehole by the selected drilling fluid. Another method is to use a solid-stem auger with a carbide auger head to grind the PVC casing into small cuttings that will be brought to the surface on the rotating flights. After the casing materials have been removed from the borehole, the borehole should be cleaned out and pressure grouted with the approved grouting materials. As previously stated, the borehole should be finished with a concrete surface plug and adequate surface protection, unless directed otherwise (EPA, 1991).

(d) State Groundwater Program Sites

i. The State Groundwater Program is administered by the Groundwater Branch of ADEM. The Groundwater Branch generally follows the most recent edition of USEPA Region IV Environmental Investigations Standard Operating Procedures (SOPs) and Quality Assurance Manual for the abandonment of monitoring wells.

ii. A well abandonment plan should be developed and submitted to the ADEM Project Hydrogeologist. ADEM approval of all well abandonment plans is required prior to implementing any well abandonment activities. Appropriate measures should be taken to protect the health and safety of individuals when abandoning a well or borehole.

iii. While this document is typically used to prepare an abandonment plan, it is understood that factors may arise that make the methods given below impractical or inappropriate for a given site. For this reason, methods other than those listed may be undertaken if prior approval is obtained.

a) As indicated in the EPA SOPs, when a decision is made to abandon a monitoring well, the borehole should be sealed in such a manner that the well can not act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers. To properly abandon a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete.

b) Abandonment Procedures

i) The well casing and screen from the borehole should be completely removed. This may be accomplished by augering with a hollow-stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig.

ii) The clean borehole can then be backfilled with the appropriate grout material.

iii) The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method).

iv) The top 2 feet of the borehole should be poured with concrete to insure a secure surface seal (plug). If the area has heavy traffic use, and/or the well locations need to be permanently marked, then a protective surface pad(s) and/or steel bumper guards should be installed. The concrete surface plug can also be recessed below ground surface if the potential for construction activities exists.

v) Wells having 6-inch or larger diameters, the use of hollow-stem augers for casing removal is very difficult or almost impossible. Instead of trying to ream the borehole with a hollow-stem auger, it is more practical to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole.

vi) Wells with little or no grouted annular space and/or sound well casings can be removed by forcing a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole.

vii) Old wells with badly corroded casing sand/or thickly grouted annular space have a tendency to twist and/or break off in the borehole. When this occurs, the well will have to be grouted with the remaining casing left in the borehole. The preferred method in this case should be to pressure grout the borehole by placing the tremie tube to the bottom of the well casing, which will be the well screen or the bottom sump area below the well screen. The pressurized grout will be forced out through the well screen into the filter material and up the inside of the well casing sealing holes and breaks that are present. The tremie tube should be retracted slowly as the grout fills the casing. The well casing should be cut off even with the ground surface and filled with concrete to a depth of 2 feet below the surface. If the casing has been broken off below the surface, the grout should be tremied to within 2 feet of the surface and then finished to the ground surface with concrete. The surface pad or specified surface protection should then be installed.

c) The following information should be included with the well abandonment plan submitted to ADEM:

i) Site name and address.

ii) Type of well(s) (monitoring, piezometer, extraction, etc.) to be abandoned and reason for abandoning.

iii) Latitude and longitude of well(s).

iv) Topographic map and site map illustrating the location of well(s).

v) Diameter and length of well(s) including length of screen and interval(s) screened prior to well abandonment.

vi) Description of method to be employed to abandon well(s).

vii) Type of grout used and method used to place grout in well.

viii) Quantity of grout used to seal well.

ix) The following information should be included in the final well abandonment report upon completion of all approved activities:

- Site name and address.
- Type of well(s) (monitoring, piezometer, extraction, etc.) abandoned and reason for abandoning.
- Identification of the well(s).
- Date well(s) was abandoned and the name of person(s) overseeing abandonment.
- Latitude and longitude of well(s).
- Site map illustrating the location of the well(s).
- Description of method employed to abandon the well(s).
- Photograph(s) of abandoned well(s).
- Date of well abandonment activities.

(e) Individual (Private) Potable Water Supply Wells

Individual water supply wells are relatively shallow in depth and serve one to several households with enough water for domestic purposes. These wells are typically one of three types: shallow-dug wells, driven or sand point wells or drilled or augered wells. As with other types of wells, the type and depth of the well should be determined prior to plugging. Any obstructions in the well should be removed prior to initiating the plugging operation and under no circumstances should any part of the casing be allowed to remain above the surface of the ground after plugging.

Accurate records (See Attachment I – Water Supply Well Abandonment Plan) should be kept of the well location, depth, filling material, date of plugging, etc.

i. Shallow-Dug Wells – Hand-dug wells that extend down to the aquifer and are sometimes blasted or chipped into bedrock to reach the aquifer. Stone or concrete walls called curbing sometimes are necessary to keep the well from collapsing. These wells are rarely deeper than a few tens of feet and have diameters that are usually several feet across.

   a) Pumps, piping or debris should be removed and the top 3 to 5 feet of curbing should be broken up prior to filling.

   b) Any portion of the well that extends into bedrock should be filled with a concrete-bentonite grout.

   c) The remainder of the well should be filled with clean native materials that approximate the permeability of the aquifer and overlying soils in the vicinity of the well.

   d) The soil should be compacted to prevent settling and ponding of water in the location of the former well.

ii. Driven or Sand Point Wells - A well that is driven to the desired depth, either by hand or machine and may employ a well-point, or alternative equipment. These wells typically have a small diameter (2 inches or less) with a short screen near the pointed end and can only be used in soft sandy sediments or soils.

   a) Driven or sand point wells should be removed if their diameter is 2 inches or less and their depth is 25 feet or less.

   b) The hole should be filled with a bentonite-cement grout.

   c) If greater than 25 feet in depth, larger than 2 inches in diameter, or cannot be removed, the well should be filled with a bentonite-cement grout from bottom to top using the pump-down method with a tremie pipe.

iii. Drilled Wells - Diameters of 2 inches to 20 inches are typical for these wells, which are installed with the use of a drilling rig and may be several tens to several thousands feet deep. In Alabama, drilled domestic wells are generally less than 250 feet deep. Drilled domestic wells are often unique in design and depth and should be abandoned only by a licensed well driller.

   a) If possible, the casing should be removed and the borehole filled with a cement-bentonite slurry.

   b) If the casing cannot be removed, the entire well should be filled with a cement-bentonite slurry using the pump-down method with a tremie pipe.

c) In areas subject to subsidence and/or farming, the top of the casing should be cut off a minimum of 3 feet below ground surface before plugging operations begin.

d) After filling the well with the cement-bentonite slurry, the excavation above the top of the cement plug should be filled with compacted soil to minimize future hazards to farming equipment, etc. In other areas, the top of the casing should be cut off at or below the ground surface.

(f) **Underground Storage Tank (UST) Petroleum Sites** - The Department may require that all installed monitoring wells be properly plugged and abandoned upon completion of either the site investigative phase or remediation phase. In accordance with ADEM ADMIN. Code R. 335-6-15-.29(8) the wells may be required to be "properly closed". The purpose of sealing an abandoned boring or monitoring well is to prevent any further disturbance to the pre-existing hydrogeologic conditions that exist in the subsurface. In accordance with this purpose, no material that could impart taste, odor, or toxic components to water may be used in the sealing process.

Allowable procedures for abandonment of the various types of wells which may be installed at a UST site are as follows:

Abandonment of Borings:

i. Unconsolidated Formations

Borings extending into unconsolidated formations may be adequately sealed by filling with concrete, grout, neat cement or a grout/cement mixture.

The boring may be backfilled with cuttings if all of the following conditions are met:

The boring is in a well-drained area with no tendency to have standing surface water,

The boring is 25 feet or less in depth,

The boring does not penetrate an aquifer, and is not in an area of contamination.

If the boring is filled with concrete, grout, neat cement or a grout/cement mixture, the sealing material may be brought up to about two or three feet below grade and finished with clay or excavated cuttings. If the boring is located in a paved area, the finishing fill should include a final covering comparable to the original surface, for example, concrete or asphalt patching. Materials that could crack and provide a vertical conduit should be avoided.

ii. *Competent Rock*

Borings that extend into competent bedrock should be filled from the bottom with concrete, grout, neat cement or a grout/cement mixture. If the bedrock is overlain by residual soils, the sealing material may be brought up to about two or three feet below grade and finished with clay or cuttings as in unconsolidated formations site is paved.

Abandonment of Monitoring Wells

Wells can be abandoned either by removing the casing or by leaving all or part of the casing in place and cutting the casing off below ground level. Because the primary purpose of well abandonment is to eliminate vertical fluid migration along the borehole, the preferred method of abandonment involves casing removal. Abandonment methods for various types of wells are as follows:

i. Temporary Monitoring Wells

Temporary monitoring wells should have the casing puled and the borehole sealed as with a boring.

ii. Permanent Monitoring Wells

Permanent monitoring wells should have the casing pulled and the borehole sealed as with a boring.

Casing material, depth of the well, deviation of the well, or other reasons may make pulling the casing impossible. In this situation, the casing may be cut off two or three feet below grade and completely filled with concrete, grout, neat cement, and or a grout/cement mixture to prevent channeling. The hole should be finished up to the ground as with a soil boring.

The casing may be removed by over-drilling if necessary. The casing and debris should be removed and borehole sealed as with a boring.

iii. Multiple Casing Monitoring Wells

Multiple cased monitoring wells are built to insure that vertical migration does not affect groundwater quality. Therefore, if the construction design is known to be satisfactory and the casing integrity has not been affected, it may be left in the ground and filled with concrete, grout, neat cement or a grout/cement mixture. The casing should be cut off two or three feet below grade and filled from the bottom up as with a permanent monitoring well. The hole should be finished up to the ground surface as with a boring.

ATTACHMENT 1 - WATER SUPPLY WELL ABANDONMENT PLAN

Name/Telephone # of well owner: ____________________________________

Name/Telephone # of person owning property on which the well is located (If different from the owner): ____

*Stage of construction: _________

Location of Well: Latitude: +Degrees_ _ Minutes _ _ _ Seconds _ _ ._ _ _
Longitude: +Degrees_ _ Minutes _ _ _ Seconds _ _ ._ _ _

Name/Telephone # of person who knows the location of the well:
____

Attach an 8 ½ x 11 copy of a 7.5 Minute USGS Topographic Map and mark the location of the well. Give the name of the topographic map (usually located in the upper right hand corner of the original map). Attach an 8½ x 11 cross sectional drawing showing the details of the well.

Type of geological formation: ___Consolidated ___Unconsolidated ___Other (Explain):____
Screen: diameter _______Type ______ Length ______
Depth of the well: ______Diameter of the casings _______________________
Casing to be removed: ___Yes ___No If no explain why not:
____
Method proposed to remove casing:____________________________________
Depth of casing grouting:________________**Type well:_________________
Describe the proposed plan for abandoning the well: ______________________
____
____
____
____
____
____
____
____

Note: Add additional pages as needed to provide complete information
* 1= Test Hole; 2=Test Well; 3=Partially completed well; 4 Completed well
** A=Rock Wall; B=Gravel wall; C=Other Explain

Appendix C

Sampling Methods

APPENDIX C - SAMPLING METHODS

C.1. Appendix Outline

C.2 Soil Sampling Methods

C.2.1 Soil Boring Drilling and Sampling Methods - Soil borings may be advanced for sampling by either manual techniques, mechanical equipment, or by specialized equipment.

(a) Manual Techniques - Manual techniques are usually selected for surface or subsurface soil sampling. As the depth of the sampling interval becomes greater, some type of power sampling equipment is usually necessary to overcome the torque induced by soil resistance. The more commonly used manual equipment are stainless steel spoons, shovels, hand-augers, post-hole diggers, push tubes and disposable syringes.

i. Stainless Steel Spoons, Shovels, Hand-Augers and Post-Hole Diggers - These sampling devices should be properly decontaminated and wrapped in aluminum foil prior to all soil sampling activities at the beginning of each day. They should also be properly decontaminated in accordance with Appendix E of this document between each sample collected and each soil boring such that cross-contamination does not occur.

ii. Split spoon samplers are manually pushed into the surface soils for the collection of a surface soil samples. Split spoon samplers are approximately 3-inches to 5-inches in diameter and may be 2 feet to 3 feet in length. The sample is transferred from the split-spoon sampler to a pan where the soil is mixed prior to being placed in the appropriate sample containers. Split spoon samplers are appropriate for use when the sample will be analyzed for volatile organic constituents, however, certain precautions must be taken. When sampling soil for VOCs using a split spoon sampler, the collected sample must either be placed in the final sample container (e.g.: 40 ml pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2 oz. soil jar) is used, the sample must be transferred to the final sample container as soon as possible not to exceed 30 minutes. After collection of the sample into an approved container, the sample must immediately be stored in an ice chest and cooled.

iii. Shelby tubes (or an equivalent) are thin-walled tube, generally of stainless steel construction and having a beveled leading edge, which is twisted and pushed directly into the soil. This type of sampling device is particularly useful if a relatively undisturbed sample is required. The sampling device is removed from the push-head, and then the sample is extruded from the tube into the pan with a spoon or special extruder. Even though the push-head is equipped with a check valve to help retain samples, the Shelby tube will generally not retain loose and watery soils, particularly of collected at lower depths.

iv. EnCore^{TM} Samplers (or an equivalent) can be used when total VOC concentrations in the soil/sediment are expected to be less than 200 μg/kg.

Samples may be collected directly with EnCore^{TM} samplers (or an equivalent). Once the sample has been collected, the sampler is simply capped and secured in a plastic bag. The sampler provides accurate in situ VOC results without the lost of VOCs that may occur during the transfer of the samples from the sampling device to the sample container. All soil samples collected by EnCore^{TM} Samplers (or an equivalent) should be extracted and analyzed by the appropriate USEPA approved SW-846 test method.

v. Disposable Plastic Syringes are also used when total VOC concentrations in the soil/sediment are expected to be less than 200 µg/kg. If using non-tared sample containers, place the sample container on the scale and zero out the weight of the container. Add about 3.7 cc (approximately) of the sample material to the 40 ml containers, 0.5 cc (approximate) to 5 ml containers and record weight to nearest 0.01 gram on the sample tag and in field notes. The final weight of the added sample material should be between 4.5 to 5.5 grams for the 40 ml containers and 0.5 to 1.5 grams for the 5 ml containers. The procedure is the same for tared containers, but the recorded weight need only be to the nearest 0.5 grams. Secure the containers in a plastic bag. When using the syringes, it is important that air is not allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample. All soil samples collected by Disposable Plastic Syringes should be extracted and analyzed by the appropriate USEPA approved SW-846 test method.

(b) Mechanical Equipment - Mechanical Equipment is typically used to advance a soil boring to depths that does not allow the use of manual boring devices. This equipment is typically used for the collection of subsurface soil samples. Mechanical equipment that is commonly used includes two-man power augers, drill rigs and backhoes.

i. Power augers of the Little Beaver variety (or an equivalent), are commonly used to aid in the collection of subsurface soil samples at depths where hand augering is impractical. This type of equipment is technically a sampling aid and not a sampling device, and on rare occasions, has been used to advance holes as deep as 40 feet below ground surface. It is used to advance a hole to the required sampling depth, at which point most commonly a hand auger, or less commonly, push tubes or split-spoons are used to collect the samples.

ii. Drill rigs offer the capacity of collecting soil samples form great depths. When used in conjunction with drilling, split-spoon samplers are usually driven either inside a hollow stem auger or inside an open borehole after rotary-drilling equipment has been temporarily removed. The spoon is driven with a 140-lb hammer through a distance of up to 24 inches and removed. Continuous split-spoon samplers are commonly used to obtain 5-foot long continuous samples.

iii. Backhoes may be used in shallow to deep subsurface soil sampling programs. Samples may be collected form the large chunks removed by the bucket or they may be collected from the trench wall, if proper safety protocols are followed. Trenches also offer the ability to collect samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. Prior to collecting samples from trench walls, the wall surface should be dressed with a stainless steel shovel, spatula knife, or spoon to remove the surface layer of soil that was smeared across the trench wall as the bucket passed. Samples from the bucket should be collected from within the large chunks that have not come into contact with the bucket surface.

(c) Specialized Direct Push Technology includes Geoprobe® and Cone Penetrometer Rigs (or their equivalents). The technology allows the sampler to obtain soil samples from the desired depths without producing drill cutting and other Investigation-Derived Waste (IDW), and to collect in situ geophysical measurements of the subsurface material. Direct push technologies are most applicable in unconsolidated sediments typically to depths less than 100 feet and have played a major role in the development of expedited site assessments. Direct Push Systems are composed of two different systems, a single-rod system, and a cased system. Soil sampling tools used with the direct push systems include non-sealed soil samplers such as barrel samplers, split-barrel samplers, and thin-wall tube samplers, and sealed soil (piston) samplers.

Presently, direct push technology may be used as a screening tool to establish the boundaries of a groundwater contamination plume, applicable for the collection soil samples, and for establishing subsurface conditions through the various geophysical tools. Permanent monitoring wells installed by conventional drill rigs will be required to verify groundwater quality conditions.

Following the collection of a soil sample, the sample container should immediately be placed in an ice chest and cooled.

C.3 Groundwater Sampling Methods

Groundwater sampling may be required for a variety of reasons such as examining potable or industrial water supplies, checking for and/or tracking contaminant plume movement in the vicinity of a land disposal or spill site, Resource Conservation Recovery Act (RCRA) compliance monitoring, and/or evaluating a site where historical information is minimal or non-existent but where it is thought that groundwater contamination may have occurred.

Groundwater samples are usually obtained from either temporary or permanently installed groundwater monitoring wells. Groundwater samples may also be obtained from a drilled boring or from a boring produced by the various direct push techniques. All groundwater samples from borings produced by drilling or a direct push technique are appropriate for screening only. A permanently installed groundwater monitoring well in accordance with Appendix B is required to verify all screening data.

C.3.1 Purging and Purge Adequacy - Purging is a process of removing stagnant water from a monitoring well immediately prior to sampling. Purging is conducted to ensure that all stagnant water has been removed from the well and that groundwater samples that are representative of actual aquifer conditions will be collected. In order to determine when a well has been adequately purged, field investigators should monitor the pH, specific conductance, temperature, and turbidity of the groundwater removed during purging. In addition, a minimum of 3 to 5 total well volumes should be removed. Prior to purging, the amount of water standing in the water column (water inside the well riser and screen) should be determined. Initially, the field investigator should determine the diameter of the well. The water level and total well depth should then be measured and recorded. Specific methods to obtain the water level and total well depth are outlined in Section C.3.2 of this Appendix. The volume of water to be purged can then be determined by using several methods. One equation is $V=0.041d^2h$, where h = depth of water in feet, d = diameter of well in inches, and V = volume of water in gallons. Alternatively, the volume may be determined using a casing volume per foot factor for the appropriate diameter well. The water level is subtracted from the total depth, providing the length of the water column. This length is multiplied by the factor in the table below that corresponds to the appropriate well diameter, providing the amount of water (gallons) contained in the well. Other appropriate methods include the use of nomographs or other equations or formulas.

Well Casing Diameter vs. Volume (Gals)/Feet of Water	
Casing Size	Gallons/Ft of Water
1	0.041
2	0.163
3	0.367
4	0.653
5	1.02
6	1.469
7	1.999
8	2.611
9	3.305
10	4.08
11	4.934
12	5.875

An adequate purge is achieved when a minimum of 3 to 5 total well volumes of standing water has been removed, and when the pH, specific conductance, and temperature of groundwater have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs). Stabilization of the groundwater chemistry parameters occurs when pH measurements remain constant with 0.1 Standard Unit (SU), specific conductance varies no more than 10 percent, and the temperature is constant for at least three consecutive reading. Standard procedure is to collect an initial set of the groundwater chemistry parameters prior to all purging activities, with a set of parameters measured after each well volume has been removed. The conditions of all purging and sampling activities should be noted in the field log and on the Groundwater Sampling Data Form. If a well is pumped or bailed dry, this is considered an adequate purge and the well can be sampled following sufficient recovery (enough volume to allow filling of all sample container). It is not necessary to evaluate the well to dryness three times before it is sampled. The pH, specific conductance, temperature, and turbidity should be measured during collection of the sample from the recovered volume, as the measurements of record for the sampling event. All efforts should be made to avoid purging monitoring wells to dryness. This may be accomplished by slowing the purge rate.

C.3.2. Water Level and Total Well Depth Measuring Techniques

(a) Measuring the depth to the free groundwater surface can be accomplished by utilizing one of the following methods: electronic water level indicators, weighted tape, chalked tape, and/or other methods (for closed systems or permanent wells - sliding float method, air line pressure method, and electrical and automatic recording methods. Acoustic water level indicators are also available). The method chosen to measure water levels should be capable of measuring to the nearest 0.1 foot. All water levels should be made to an established reference point on the well casing. The reference point should be tied in with the NGVD (National Geodetic Vertical Datum). All water levels should be documented in the field records and on a Groundwater Sampling Data Form.

(b) The total well depth measurement techniques, which can be used to determine the total well depth, include the bell sounder, weighted tape, and electronic water level indicators. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. All total well depth measurements should be made and recorded to the nearest 0.1 foot. All total well depth measurements should be made to an established reference point on the well casing. The reference point should be tied in with the NGVD. All total well depth measurements should be documented in the field records and on a Groundwater Sampling Data Form. All water level and total depth measuring equipment should be decontaminated in accordance with decontamination procedures outlined in Appendix E.

C.3.3 Purging Techniques – Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or , by using portable pumps/equipment when dedicated systems are not present. The equipment may consist of a variety of pumps, including peristaltic, large and small diameter turbine (electrical submersible), bladder, centrifugal, gear-driven positive displacement, or other appropriate pumps. The use of any of these pumps is usually a function of the depth of the well being sampled and the amount of water that is to be removed during purging. Whenever the head difference between the sampling location and the water level is less thanthe limit of suction and the volume to be removed is reasonably small, a peristaltic pump should be used for purging. Bailers may also be used for purging in appropriate situations. If a bailer is used it should be a closed-top bailer to attempt to inhibit turbid conditions.

The pump/hose assembly or bailer used in purging should be lowered into the top of the standing water column to pull water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representatives of the groundwater. After the pump is removed from the well, all wetted portions of the hose and the pump should be cleaned as outlined in Appendix E. Careful consideration should be given to using pumps to purge wells, which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative purging methods, such as bailers, should be considered.

(a) Wells Without Plumbing or In-Place Pumps

  i. Purging with Pumps - When peristaltic pumps or centrifugal pumps are used, only the intake line is placed into the water column. The line placed into the water should be either standard-cleaned (See Appendix E) Teflon® tubing for peristaltic pumps, or standard-cleaned stainless steel pipe attached to a hose for centrifugal pumps. When submersible pumps (bladder, turbine, displacement, etc.) are used, the pump itself is lowered into the water column. The pump should be cleaned as specified in Appendix E of this document.

  ii. Purging with Bailers - Standard-cleaned closed-top Teflon® bailers with Teflon® leaders and arid new nylon rope are lowered into top of the water column, allowed to fill, and removed. The water should be contained and managed as investigation-derived waste. It is critical that bailers are slowly and gently immersed into the tip of the water column, particularly during the final stages of purging, to minimize turbidity and disturbance of volatile organic constituents.

  iii. General Low Flow/Low Stress Method Preference - Low flow/low stress purging is a procedure using a device with the lowest pump or water removal rate, and creating the least amount of stress to a well. If a bailer and a peristaltic pump both works in a given situation, the pump should be selected because it will greatly minimize turbidity, providing a higher quality sample. If a Fultz® pump or a Grundfos Redi-Flo® (or their equivalents) could both be used, the Redi-Flo® (or its equivalent) may be given preference because the speed can be controlled to provide a lower pump rate, thereby minimizing turbidity.

  iv. Low flow/low volume purging techniques/procedures are procedure(s) used to minimize purged water volumes. Flow rates do not exceed the recharge rate of the aquifer (no decrease in the water level in the monitoring well). The pump intake is placed within the screened interval at the zone of sampling, preferably, the zone with the highest flow rate. The water level is monitored with a water level recorder or similar device while pumping. These techniques are only acceptable under certain hydraulic conditions and are not considered standard procedures. A plan documenting that the required hydraulic conditions do exist at the site under investigation will be required for ADEM review and approval determination.

(b) Wells with In-Place Plumbing

  i. Permanent Monitoring Wells - Permanent monitoring wells generally are sampled only occasionally and require purging as described for wells without in-place pumps (i.e.:, 3 to 5 well volumes and stable parameters).

  ii. Continuous Running Pumps - If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be located between the pump and the storage tank. Otherwise, locate the valve closest to the tank. Measurements of pH, specific conductance, temperature, and turbidity are recorded at the time of sampling.

iii. Intermittently Running Pumps - If the pump runs intermittently, it is necessary to determine, if possible, the volume to be purged, including storage/pressure tanks that are located prior to the sampling location. The pump should then be run continuously until the required volume has been purged. If construction characteristics are not known, best judgment should be used in establishing how long to run the pump prior to collecting the sample. Generally, under these conditions, 30 minutes will be adequate. Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purging, and the final measurements made at the time of the sampling.

(c) Temporary monitoring wells from permanent wells because temporary wells are installed in the groundwater for immediate sample acquisition. Wells of this type may include standard well screen and riser placed in boreholes created by hand augering, power augering, or by drilling. They may also consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as the Direct Push Wellpoint®, the Geoprobe® and the Hydropunch® (or their equivalents). As such, the efforts to remove several volumes of water to replace stagnant water do not necessarily apply in these situations because, generally, stagnant water is non-existent. However, the longer a temporary well is in place and not sampled, the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria to it. Temporary wells to be sampled immediately may require purging to mitigate the impacts of the installation activities that have resulted in increased turbidity. Therefore, purging may be conducted to reduce the turbidity and remove the volume of water in the area directly impacted by the installation activities. If the water level is no greater than approximately 25 feet below the pump head elevation, a peristaltic pump may be used to purge temporary monitoring wells and collect low turbidity samples by low-flow purging and sampling techniques. At the onset of purging, the tubing should be slowly lowered to the bottom of the screen and used to remove any formation material which may have entered the well screen. After formation material is removed from the bottom of the well, the tubing is slowly raised through the water column to near the top of the column. If the water level is determined to be stable, the tubing should be secured and maintain this pumping rate until relatively clear, low turbidity water samples can be collected. If the water level is lowered, and the pump is not in a variable speed, continue to lower the tubing as the water level is lowered. If the water level continues to lower, “chase” the water column until the well is evacuated. The recovered water column, after complete evacuation of the well, may be relatively free of turbidity and can be sampled. It may take several episodes of recovery to provide an adequate volume of water for all required samples. If a variable speed peristaltic pump is being used and drawdown is observed on initiation of pumping, reduce the pump speed and attempt to match the drawdown of the well. Sustained pumping at these slow rates should be conducted until relatively clear, low turbidity water samples can be collected. With many of the direct push sampling techniques, no purging is conducted. The sampling device is simply pushed to the desired depth, opened, and the sample is collected and retrieved.

C.4. Groundwater Sampling

Groundwater sampling is the process of obtaining, containerizing, and preserving a groundwater sample after the purging process is complete. Submersible, centrifugal and Fultz® pumps (or their equivalents) are not appropriate for the collection of groundwater samples from any monitoring wells. The only devices that should be used to collect groundwater samples from monitoring wells are: peristaltic pump/vacuum jug assembly, a stainless steel and Teflon® bladder pump, and a closed-top, Teflon® bailer (or its equivalent). Industrial or municipal supply wells or private residential wells, where a well may be equipped with a dedicated pump from which a sample would not normally be collected, should be sampled in accordance to this guidance document and USEPA Region 4 Standard Operating Procedures and Quality Assurance Manual (recent edition). Groundwater samples should be collected in the order of the volatilization (highest ability to volatilize to the lowest). Groundwater samples for VOC analysis should be collected initially prior to all other samples. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which comes into contact with the water in the well must be decontaminated in accordance with the decontamination procedures as described in Appendix E prior to its use in all subsequent monitoring wells. When conducting groundwater sampling, the following evaluations should also be conducted and noted in the field logbook and in a Groundwater Sampling Data Form. First, determine the order in which the wells will be sampled (least contaminated to the most contaminated). Note the construction and condition of the well (pad condition, ponding of water, or vertical openings between the casing and the backfill material). Note any standing water inside the protective casing (if this freezes, may collapse casing). There should be a weep hole at the bottom of the protective casing to prevent standing water. Note if the well is locked and the condition of the lock (broken, rusted, or missing). Note the condition of all well construction materials and any damage that may need to be repaired, or if the well should be abandoned and replaced. Check for dangerous vapors with the proper air monitoring equipment. Finally, note the time of the sampling, the sample station location, the method of sampling, the color of sample, any odors detected, and any sediment observed.

C.4.1 Sampling Techniques

(a) Monitoring Wells with In-Place Plumbing - Following all purging activities, reduce the flow rate to minimize sample disturbance (particularly if VOCs are the COPCs). If the well is purged to dryness, the pump should be shut off and the well should be allowed to recharge such that the required groundwater samples can be collected. Collect all groundwater samples from dedicated, decontaminated Teflon® tubing directly into the appropriate sample containers.

(b) Potable Water Supply Wells with In-Place Plumbing - Purge the system for at least 15 minutes. If the samples must be collected at a point in the water line beyond pressurization or holding tank, a sufficient volume of water should be purged to provide a complete exchange of fresh water into the tank and at the location where the sample is collected. After purging for 15 minutes, measure the turbidity, pH, specific conductivity and temperature of the groundwater. Continue to monitor these parameters until three consistent readings are obtained. Disconnect any hoses, filters, or aerators attached to the tap before sampling. Reduce the flow rate of the tap or spigot and collect all groundwater samples directly into the appropriate sample containers (see Table 1 of Appendix G). When sampling for bacterial content, the sample container should not be rinsed before use due to possible contamination of the sample container or removal of the thiosulfate dechlorinating agent (if used). When filling the sample container, care should be taken so that splashing drops of water from the ground or sink do not enter into either the bottle or cap. Obtain the name(s) of the resident or water supply owner/operator, the resident's exact mailing address, and the resident's home and work telephone numbers.

(c) Wells Without Pumps

i. A peristaltic pump/vacuum jug can be used for sample collection because it does not allow the sample to come into contact with the pump tubing. Place a Teflon® transfer cap assembly onto the neck of a standard cleaned 4-liter (1-gallon) glass container. Connect Teflon® tubing (1/4-inch outside diameter) from the glass container to both the pump and the sample source. The pump creates the vacuum in the container, thereby drawing the sample into the container without it coming into contact with the pump tubing. Samples for VOC analysis should be collected using a bailer or by filling the Teflon® tube, by one of two methods, and allowing it to drain into the sample vials. The tubing is momentarily attached to the pump to fill the tube with water. After the water is discharged through the pump head, the tubing is quickly removed from the pump and a gloved thumb placed on the tubing to stop the water from draining out. The tubing is then removed from the well and the water is allowed to drain into the sample vials. The tubing is lowered into the well at the desired depth. A gloved thumb is placed over the end of the tubing to stop the water from draining out. The tubing is then removed from the well and the water is allowed to drain into the sample vials. Under no circumstances should the sample for VOC analysis be collected from the content of any other previously filled container.

ii. Bladder Pumps - After purging is completed with the bladder pump, the sample should be collected directly from the pump discharge. If the discharge rate of the pump during the purging is too great, so as to make sample collection difficult, care should be taken to reduce the discharge rate at the onset of actual sample collection. This is necessary to minimize sample disturbance, particularly with respect to samples collected for VOC analysis.

iii. Bailers - Place new plastic sheeting on the ground around each well to provide a clean working area. Attach nylon rope to the bailer. Lower the bailer slowly and gently into the top of the water column until just filled. Carefully remove the bailer and empty its contents into the appropriate sample containers (see Table 1 of Appendix G).

(d) Direct-Push Technologies - Groundwater sampling using direct push (DP) technology is generally used during a one-time sampling event, and for screening purposes only. Once the contamination plume is delineated using DP technology, permanent monitoring wells installed using conventional methods should be used to verify DP screening results. Permanent wells installed utilizing direct push technologies is program dependent and determined site-specifically. A plan should be submitted to the Department and approved prior to any small diameter permanent well installation (see Appendix B-3). DP technology may also be used for determining groundwater gradients early in the site investigation. DP tools used for single-event sampling are divided into two groups – exposed-screen samplers and sealed-screen samplers. Exposed-screen samplers have a short (e.g.: 6 inches to 3 feet) interval of exposed fine mesh screens, narrow slots, or small holes at the terminal end of the tool. There are several varieties of exposed-screen samplers – a well point, drive-point profiler, and an innovative exposed-screen sampler used in conjunction with cone penetrometer testing. The advantage of the exposed screen is that it allows multi-level sampling in a single DP hole without withdrawing the DP rods. The disadvantages of the exposed screen are the following:

i. Dragging down of NAPLs, contaminated soil, and/or contaminated groundwater in the screen can occur;

ii. Clogging of the exposed screen (by silts and clays) typically occurs as it passes through sediments;

iii. Significant purging of sampler and/or the sampling zone because of drag down and clogging concerns are necessary; and,

iv. The fragility of the sampler because of the perforated open area.

Sealed-screened samplers are groundwater samplers that contain a well screen nested inside a watertight sealed body. The screen is exposed by retracting the probe rods once the desired sampling depth has been reached. The design of sealed-screen samplers is extremely variable. The advantages of sealed-screen samplers are the following:

i. The well screen is not exposed to soil while the tool is being pushed to the depth, thus, the screen cannot become plugged or damaged;

ii. The potential for sample cross-contamination is greatly reduced;

iii. Can collect depth-discrete groundwater samples beneath areas with soil in the vadose zone;

iv. Screened samplers do not require purging;

v. Some allow sample collection by bailers, check-valve pumps, peristaltic pumps, and bladder pumps (used with wide diameter cased DP systems only); and,

vi. Can be used in cased DP systems for the collection of deeper groundwater samples.

The disadvantages of this type of sampler are:

i. The o-rings must be replaced frequently; and,

ii. Sealed-screened samplers that collect groundwater in sealed chambers:

   A. if the storage chamber is above the screen intake, groundwater samples must be collected sufficiently below the water table to create enough hydrostatic pressure to fill the chamber; and,

   B. only sample chambers located below the screen intake are useful for collecting groundwater or LNAPL samples at or above the water table.

C.4.2 Sample Preservation - The minimum amount of preservative needed should be added to the sample immediately (See Table 1 of Appendix G). Care should be taken not to touch the preservative container to the sample bottle. After preserving, the sample pH should be checked by pouring a small volume over a piece of pH paper. Do not put pH-paper or probe into the sample container. Sample preservation should be done ASAP. Laboratories that supply the required sample containers may submit all containers with the required preservative. These sample containers are appropriate; however, the pH of the final sample should be checked with the results recorded in the field logbook and Groundwater Sampling Data Form.

C.4.3 Special Sample Collection Procedures

(a) Trace Organic Compounds and Metals - All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which comes into contact with the water in the well, should be decontaminated in accordance with the decontamination procedures described in Appendix E of this document. Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly decontaminated (Appendix E). Blank samples should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump. Filtered groundwater sample results will not be accepted as representative of existing aquifer conditions.

(b) Filtering will only be used for flow system analysis and for the purpose of geochemical speciation modeling.

(c) Bacterial Sampling - Whenever wells (normally potable wells) are sampled for bacteriological parameters, care should be taken to ensure the sterility of all sampling equipment and all other equipment entering the well.

C.4.4 Specific Sampling Equipment Quality Assurance Techniques - All equipment used to collect groundwater samples should be cleaned and repaired, if necessary, before being stored at the conclusion of field studies as outlined in Appendix E of this document. Cleaning procedures or repairs utilized in the field should be thoroughly documented in the field records or field logbook.

C.5. Surface Water and Sediment Sampling

Before any sampling is conducted, an initial reconnaissance should be made to locate suitable sampling locations. Bridges and piers are normally good choices as sites since they provide ready access and permit water sampling at any point across the width of the water body. However, these structures may alter the nature of the water flow and thus influence sediment deposition or scouring. Additionally, bridges and piers are not always located in desirable locations with reference to waste sources, tributaries, etc. Wading for water samples in lakes, ponds and slow-moving rivers and streams should be done with caution since bottom deposits are easily disturbed, thereby resulting in increased sediments in the overlying water column. On the other hand, wadeable area may be best for sediment sampling. In slow-moving or deep water, a boat is usually required for sampling.

C.5.1 Sampling Site Selection

(a) Rivers, Streams and Creeks - In the selection of a surface water sampling site in rivers, streams, or creeks, areas that exhibit the greatest degree of cross-section homogeneity should be located. When several locations along a stream reach are to be sampled, they should be strategically located at the following locations:

  i. At intervals based on time of water travel, not distance (e.g.: sampling stations may be located about one-half day time-of-water-travel for the first three days downstream of a waste source (the first six stations) and then approximately one day through the remaining distance).

  ii. At the same locations, if possible, when the data collected are to be compared to a previous study.

  iii. Wherever a marked physical change occurs in the stream channel. When major changes occur in a stream reach, an upstream, downstream, and intermediate stations should be selected. Major changes may consist of:

    A. A wastewater discharge;
    B. A tributary flow;
    C. Non-point source discharge (farms or industrial sites); and,
    D. A significant difference in channel characteristics.

  iv. To isolate major discharges as well as major tributaries. Dams and weirs cause changes in the physical characteristics of a stream. They usually create quiet, deep pools in river reaches that previously were swift and shallow. Such impoundments should be bracketed with sampling stations. When time-of-water-travel through the pools is long, stations should be established within the impoundments. To determine the effects of certain discharges or tributary streams on ambient water quality, stations should be located both upstream and downstream from the discharges. In addition to the upstream and downstream stations bracketing a tributary, a station should be established on the tributary at a location upstream and out of the influence of the receiving stream. Tributaries should be sampled as near the mouth as feasible. Frequently, the mouths of tributaries are accessible by boat. Care should be exercised to avoid collecting water samples from stratified locations that are due to difference in density resulting from temperature, dissolved solids, or turbidity.

v. Actual sampling locations will vary with the size of the water body and the mixing characteristics of the stream or river. Generally, for small streams less than 20 feet wide, a sampling site should be selected where the water is well mixed. In such cases, a single grab sample taken at mid-depth at the center of the channel is adequate to represent the entire cross-section. A sediment sample could also be collected in the same vicinity if available.

vi. For slightly large streams, at least one vertical composite should be collected from mid-stream. Samples should be collected just below the surface, at mid-depth, and just above the bottom. For larger streams and rivers, at least quarter point (¼, ½, and ¾ width) composite samples should be collected. Dissolved oxygen, pH, temperature, and conductivity should be measured from each aliquot of the vertical composite.

vii. For large rivers, several locations across the channel width should be sampled. Vertical composites across the channel width should be located in a manner that is roughly proportional to the flow (*i.e.,* they should be closer together toward mid-channel where most of the flow is, than toward the banks where the proportion of total flow is less).

In most circumstances, a number of sediment samples should be collected along a cross section of a river or stream in order to adequately characterize the bed material. A common procedure is to sample at quarter points along the cross-section. When the sampling technique or equipment requires that the samples be extruded or transferred on-site, they may be combined into a single composite sample. However, samples of dissimilar composition should not be combined but should be stored for separate analysis in the laboratory. To insure representative samples, the preferred method is diver-deployed coring tubes.

(b) Lakes, Ponds, and Impoundments - Lakes, ponds, and impoundments have a much greater tendency to stratify than rivers and streams. The relative lack of mixing generally requires that more samples be obtained. Occasionally, an extreme turbidity difference may occur where a highly turbid river enters a lake. For these situations, each layer of the vertically stratified water column needs to be considered. The number of water sampling stations on a lake, pond, or impoundment will vary with the objective of the investigation as well as the size and shape of the basin. In ponds and small impoundments, a single vertical composite at the deepest point may be sufficient. Dissolved oxygen, pH, and temperature are generally measured for each vertical composite aliquot. In naturally-formed ponds, the deepest point is usually near the center; in impoundments, the deepest point is usually near the dam. In lakes and larger impoundments, several vertical subsamples should be composited to form a single sample. These vertical sampling locations are often collected along a transection or grid. In lakes with irregular shapes and with several bays and coves that are protected from the wind, additional separate composite samples may need to adequately determine water quality. Similarly, additional samples should be collected where discharges, tributaries, land use characteristics, etc., are suspected of influencing water quality. When collecting sediment samples in lakes, ponds, and reservoirs, the sampling site should be approximately at the center of the water mass. The shape, inflow pattern, bathymetry, and circulation should be considered when selecting sediment-sampling sites in lakes or reservoirs.

(c) Estuarine Waters - A reconnaissance investigation should be conducted for each estuarine study unless prior knowledge of the estuarine type is available. The reconnaissance should focus upon the freshwater and oceanic water dynamics with respect to the study objective of the National Oceanic Atmospheric Administration (NOAA) tide tables and United States Geological Survey (USGS) freshwater surface water flow records that provide valuable insights into the estuary hydrodynamics. Water sampling in estuarine areas is normally based upon the tidal phases, with samples collected on successive slack tides. All estuarine sampling should include vertical salinity measurements at one to five-foot increments coupled with vertical dissolved oxygen and temperature profiles. A variety of water sampling devices are used, but in general, the Van Dorn (or similar type) horizontal sampler or peristaltic pump are suitable. Samples are normally collected at mid-depth areas where the depths are less than 10 feet unless the salinity profile indicates the presence of a halocline (salinity stratification). In that case, samples are collected from each stratum. Depending upon the study objective, when depths are greater than 10 feet, water samples may be collected at the one-foot depth from the surface, mid-depth, and one-foot from the bottom. Generally, estuarine investigations are two-phased, with study investigations conducted during wet and dry periods. Depending upon the freshwater inflow sources, estuarine water quality dynamics cannot normally be determined by a single season study.

(d) Control Stations - In order to have a basis of comparison of water quality, the collection of samples from control stations is always necessary. A control station upstream from the waste source is as important as the stations downgradient, and should be chosen with equal care to ensure representative results. In some situations it is desirable to have background stations located in similar, nearby estuaries that are not impacted by the phenomena or pollutants being investigated. At times it may be desirable to locate two or three stations downstream from the waste inflow to establish the rate at which the unstable material is changing.

C.5.2 Surface Water Sampling Equipment

(a) Dipping Using Sample Container - A sample may be collected directly into the sample container when the surface water source is accessible by wading or other means. The sampler should face upstream and collect the sample without disturbing the sediment. The surface water sample should always be collected prior to a sediment sample at the same location. The sampler should be careful not to displace the preservative from a pre-preserved sample container such as the 40-mil VOC vial.

(b) Scoops - Stainless steel scoops are useful for reaching out into a body of water to collect a surface water sample. The scoop may be used directly to collect and transfer a surface water sample to the sample container, or it may be attached to an extension in order to access the selected sampling location. The scoop is one of the most versatile sampling tools available to the field investigator.

(c) Peristaltic Pumps - Another device that can be effectively used to sample a water column is the peristaltic pump/vacuum jug system. The use of a metal conduit to which the tubing is attached allows for the collection of a vertical sample (up to about a 25-foot depth) that is representative of the water column. Commercially available pumps vary in size and capability with some being designed specifically for the simultaneous collection of multiple water samples.

(d) Discrete Depth Samplers - When discrete samples are desired from a specific depth, and the parameters to be measured do not require a Teflon® coated sampler, a standard Kemmerer or Van Dorn sampler may be used. The Kemmerer sampler is a brass cylinder with rubber stoppers that leave the ends of the sampler open while being lowered in a vertical position, thus allowing free passage of water through the cylinder. The Van Dorn sampler is plastic and is lowered in a horizontal position. In each case, a messenger is sent down a rope when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill respective sample containers. With a rubber tube attached to the valve, dissolved oxygen sample bottles can be properly filled by allowing an overflow of the collected water. With multiple depth samples, care should be taken not to stir up the bottom sediment and thus bias the sample.

(e) Bailers - Teflon® bailers may also be used for surface water sampling if the study objectives do not necessitate a sample from a discrete interval of the water column. A closed top bailer with a bottom check-valve is sufficient for many studies. As the bailer is lowered through the water column, water is continually displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. This technique may not be successful where strong currents are found.

(f) Buckets - A plastic bucket can be used to collect samples for in situ analyses (*e.g.*, pH, temperature and conductivity). However, the bucket should be rinsed twice with the sample water prior to collection of the sample.

C.5.3 Sediment Sampling Equipment

(a) Scoops and Spoons - If the surface water body is wadeable, sediment samples should be collected by using a stainless steel scoop or spoon. The sample is collected by wading into the surface water body and, while facing upstream (into the current), scooping the sample along the bottom of the surface water body in the upstream direction. Excess water may be removed from the scoop or spoon. However, this may result in the loss of some fine particle size material associated with the bottom of the surface water body. Aliquots of the sample are then placed in a glass pan and homogenized. In surface water bodies that are too deep to wade, but less than eight feet deep, a stainless steel scoop or spoon attached to a piece of conduit can be used either from the banks if the surface water body is narrow or from a boat. The sediment is placed into a glass pan and homogenized. If the surface water body has a significant flow and is too deep to wade, a BMH-60 sampler may be used. The BMH-60 is not particularly efficient in mud or other soft substrates because its weight will cause penetration to deeper sediments, thus missing the most recently deposited material at the sediment water interface. It is also difficult to release secured samples in an undisturbed fashion that would readily permit subsampling. The BNH-60 may be used provided that caution is exercised by only taking subsamples that have not been in contact with the metal wall of the sampler.

(b) Dredges - For routine analyses, the Peterson dredge can be used when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches bottom since it can displace and miss fine particle size sediment it allowed to drop freely. The Eckman dredge has only limited usefulness. It performs well where the bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky and hard bottoms, and is too light for use in streams with high velocities. It should not be used from a bridge that is more than a few feet above the water because the spring mechanism, which activates the sampler, can be damaged by the messenger if dropped from too great a height. The Ponar dredge is a modification of the Peterson dredge and is similar in size and weight. It has been modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing turbulence around the dredge. The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates. The “mini” Ponar dredge is a smaller, much lighter version of the Ponar dredge. It is used to collect smaller sample volumes when working in industrial tanks, lagoons, ponds, and shallow water bodies. It is a good device to use when collecting sludge and sediment containing hazardous constituents because the size of the dredge makes it more amenable to field cleaning.

(c) Coring – Core samplers are used to sample vertical columns of sediment. They are particularly useful when a historical picture of sediment deposition is desired since they preserved the sequential layering of the deposit, and when it is desirable to minimize the loss of material at the sediment-water interface. Many types of coring devices have been developed depending on the depth of the water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand push tubes to weight or gravity driven devices. Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus fines of the sediment-water interface are only minimally disturbed. The sample is withdrawn intact permitting the removal of only those layers of interest. Core liners manufactured of glass or Teflon® can be purchased; thus, reducing possible sample contamination and the samples are easily delivered to the lab for analysis in the tube in which they are collected. The disadvantage of coring devices is that a relatively small surface area and sample size is obtained often necessitating repetitive sampling in order to obtain the required amount of material for analysis. Because it is believed that this disadvantage is offset by the advantages, coring devices are recommended in sampling sediments for trace organic compounds or metals analyses. In shallow, wadeable waters, the direct use of a core liner or tube manufactured by Teflon®, plastic, or glass is recommended by the USEPA Region 4 for the collection of sediment samples. Teflon® or plastic is preferred to glass since they are unbreakable which reduces the possibility of sample loss. Stainless steel push tubes are also appropriate and provide a better cutting edge and higher strength than Teflon®. The use of glass or Teflon® tubes eliminates any possible metals contamination from core barrels, cutting heads, and retainers. The tube should be approximately 12 inches in length if only recently deposited sediments (8 inches or less) are to be sampled. Longer tubes should be used when the depth of the substrate exceeds 8 inches. Soft or semi-consolidated sediments such as mud and clays have a greater adherence to the inside of the tube and thus can be sampled with larger diameter tubes. Because coarse or unconsolidated sediments such as sands and gravel tend to fall out of the tube, a small diameter is required for them. A tube about two inches in diameter is usually the best size. The thickness of the tube wall should be about 1/3 inch for Teflon®, plastic or glass. The core tube is pushed into the substrate until four 4 inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction. The top of the tube is then capped to provide suction and reduce the chance of losing the sample. A Teflon® plug or a sheet of Teflon® held in place by a rubber stopper or cork may be used. After capping, the tube is slowly extracted with the suction and adherence of the sediment keeping the sample in the tube. Before pulling the bottom part of the core above the water surface, it too should be capped.

Appendix D

Quality Assurance/Quality Control

APPENDIX D - QUALITY ASSURANCE/QUALITY CONTROL

D.1. Outline

D.2. QA/QC Requirements

Quality Assurance/Quality Control procedures, and EPA required decontamination procedures should be utilized to ensure sample quality. (See USEPA Region IV's Standard Operating Procedures and Quality Assurance Manual – latest edition). It is the responsibility of the field sampling staff to assure that the samples collected arrives at the laboratory in the appropriate container, with the appropriate preservative, and within the holding times for each analysis.

D.3. Sample Containers & Preservation

All samples should be placed in the appropriate containers and preserved as recommended in Table 1 of Appendix G of this document. All sample containers should be new, pre-cleaned or properly decontaminated with the appropriate certification.

D.4. Sample Handling

The effectiveness of sample handling techniques will be measured by collecting split and blank samples. Blanks are required of water systems, grout, preservatives, sand, bentonite, soil trip blanks, and field cleaned equipment. The following samples are examples of Quality Control Samples that may be collected or required:

D.4.1 Control Sample - Typically a discrete grab sample collected to isolate a source of contamination. Isolation of a source could require the collection of both an upstream sample at a location where the medium being studied is unaffected by the site being studied, as well as a downstream control that could be affected by contaminants contributed from the site under study.

D.4.2 Background Sample - A sample (usually a grab sample) collected from an area, water body, or site similar to the one being studied, but located in an area known or thought to be free from the constituents of concern.

D.4.3 Split Sample - A sample that has been portioned into two or more containers from a single sample container or sample mixing container. The primary purpose of a split sample is to measure sample handling variability.

D.4.4 Duplicate Sample - two or more samples collected from a common source. The purpose of a duplicate sample is to estimate the variability of a given characteristic or contaminant associated with a population.

D.4.5 Trip Blanks - A sample that is prepared prior to the sampling event in the actual container and is stored with the investigative samples throughout the sampling event. They are then packaged for shipment with the other samples and submitted for analysis. At no time after their preparation are trip blanks to be opened before the reach the laboratory. Trip blanks are used to determine if samples were contaminated during storage and/or transport back to the laboratory (a measure of sample handling variability resulting in positive bias in contaminant concentration). If samples are to be shipped, trip blanks are to be provided with each shipment but not for each cooler.

D.4.6 Spike - A sample with known concentrations of contaminants. Spike samples are often packaged for shipment with other samples and sent for analysis. At no time after their preparation are the sample containers to be opened before they reach the laboratory. Spike samples are used to measure negative bias due to sample handling or analytical procedures or to assess the performance of a laboratory.

D.4.7 Equipment Field Blank - A sample collected using organic-free water that has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. Equipment field blanks are often associated with collecting rinse blanks of equipment that has been field-cleaned.

D.4.8 Pre- and Post-Preservative Blank - A sample that is prepared in the field and used to determine if the preservative used during field operations was contaminated, thereby, casing a positive bias in the contaminant concentration. On small studies, usually only a post-preservative blank is prepared at the end of all sampling activities. On studies extending beyond one week, a pre-preservative blank should also be prepared prior to beginning sampling activities. At the discretion of the project leader, additional preservative blanks can be prepared at intervals throughout the field investigation. These blanks are prepared by putting organic/analyte-free water in the container and then preserving the sample with the appropriate preservative.

D.4.9 Field Blank - A sample that is prepared in the field to evaluate the potential for contamination of a sample by site contaminants from a source not associated with the sample collected (e.g.: air-borne dust or organic vapors that could contaminate a soil sample). Organic-free water is taken to the field in sealed containers or generated on-site. The water is poured into the appropriate sample containers at pre-designed locations at the site. Field blanks should be collected in dusty environments and/or from areas where volatile organic contamination is present in the atmosphere and originating from a source other than the source being sampled.

D.4.10 Material Blanks - Samples of sampling materials, construction materials, or reagents collected to measure any positive bias from sample handling variability. Commonly collected material blanks are:

(a) Wipe Sample Blank – a sample of the material used for collecting wipe samples.

(b) Grout Blank – a sample of the material used to make seals around the annular space in monitoring wells.

(c) Filter Pack Blank – a sample of the material used to create an interface around the screened interval of a monitoring well.

(d) Construction Water Blank – a sample of the water used to mix or hydrate construction material such as monitoring well grout.

(e) Organic/Analyte Free Water Blank – a sample collected from a field organic/analyte free water generating system. The sample is normally collected at the end of sampling activities since the organic/analyte-free water system is recharged prior to use on a study. On large studies, samples can be collected at intervals at the discretion of the project leader. The purpose of the organic/ analyte-free water blank is to measure positive bias from the sample handling variability due to possible localized contamination of the organic/analyte-free water-generating system or contamination introduced to the sample containers during storage at the site. Organic/analyte-free water blanks differ from field blanks in that the sample should be collected in as clean an area as possible.

D.5. Sample Identification

1. Samples collected for specific field analysis or measurement data should be recorded directly in bound field logbooks, sample collection forms, or recorded directly on the Chain-of-Custody Record. Samples collected for laboratory analyses should include sample labels or sample tags. The following information should be written on the sample labels or tags using waterproof, non-erasable ink:

(a) Project number;
(b) Field identification or sample station number;
(c) Date and time of sample collection;
(d) Designation of the sample as a grab or composite;
(e) Type of sample (water, wastewater, leachate, soil, sediment, etc.);
(f) The preservative used (if any); and

(g) The general types of analyses to be performed.

2. Information to be retained in a bound logbook or sample collection form should include:

   (a) Project number;

   (b) Field identification or sample station number;

   (c) Date and time of sample collection;

   (d) Designation of the sample as a grab or composite;

   (e) The signature of either the sampler(s) or the designated sampling team leader and the field sample custodian;

   (f) Whether the sample was preserved or unpreserved, and if preserved, identify the preservative used;

   (g) The general types of analyses to be performed;

   (h) All field measurements collected during the purging of monitoring wells (pH, Specific Conductivity, Temperature, and Turbidity);

   (i) Water levels and total well depths measured during the sampling event; and,

   (j) Any relevant comments (such as readily detectable or identifiable odor, color, or known toxic properties).

D.6. Chain-of-Custody

The original or copies of the chain-of-custody forms should be submitted with all the original laboratory reports to the Department. If copies are submitted, the copies should represent the same data and information, which are present on the original chain-of-custody forms. All information on the chain-of-custody forms should be recorded in a legible manner. Chain-of-custody forms should originate in the field immediately upon sampling soils or groundwater. The chain-of-custody forms should stay with the samples at all times until properly relinquished to the laboratory for analysis. Information which should be present on all chain-of-custody forms includes the following:

1. Site name and address.
2. Date and time of sampling of each sample.
3. Sample identification numbers.
4. Name of sampler(s).
5. Analytical laboratory to be utilized.
6. Analytical methods to be used.
7. Type of sample (i.e.: composite, grab, etc.).
8. Matrix sampled (soil, water sludge, etc.).
9. Number and type of sample container.
10. Remarks regarding sampling, if applicable.

11. Preservatives used for each sample (also indicate if placed on ice).
12. Personnel relinquishing samples; times and dates.
13. Personnel receiving samples; times and dates.

D.7. Investigation Derived Waste (IDW)

A number of materials may become IDW. Personnel protective equipment (PPE) (e.g.: disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.), Disposable equipment (e.g.: plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers, Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.), soil cuttings from drilling or hand augering, drilling mud or water used for water rotary drilling, ground water obtained through well development or well purging, cleaning fluids such as spent solvents and washwater and packing and shipping materials. All IDW (non-hazardous and hazardous) shall be handled and disposed in accordance with Table 2, located in Appendix G.

Appendix E

Field Decontamination Procedures

APPENDIX E - FIELD DECONTAMINATION PROCEDURES

E.1. Appendix Outline

E.2. Standard Cleaning Liquids

1. Soap should be a standard brand of phosphate-free laboratory detergent such as Liquinox®. Use of other detergent should be justified and documented in the field logbooks and inspection or investigative reports.

2. Solvent should be pesticide-grade isopropanol. Use of a solvent other than pesticide-grade isopropanol for equipment cleaning purposes should be justified in the study plan. Otherwise its use should be documented in field logbooks and inspection or investigative reports.

3. Tap water may be used from any municipal water treatment system. Use of an untreated potable water supply is not an appropriate substitute for tap water. Analyte free water (deionized water) is tap water that has been treated by passing through a standard

deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e.: at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Analyte-free water obtained by other methods is appropriate as long as it meets the above analytical criteria. Organic/analyte free water is defined as tap water that has been treated with activated carbon and deionizing units. A portable system to produce organic/analyte free water under field conditions is available. At a minimum, the finished water should meet the analytical criteria of analyte free water and should contain no detectable pesticides, herbicides, or extractable organic compounds, and no VOCs above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic/analyte free water obtained by other methods is appropriate, as long as it meets the above analytical criteria.

4. Other solvents may be substituted for a particular purpose if required. For example, removal of concentrated waste materials may require the use of either pesticide-grade hexane or petroleum ether. After the waste material is removed, the equipment should be subjected to the standard cleaning procedure. Because these solvents are not miscible with water, the equipment should be completely dry prior to use.

E.3. Decontamination Pad

E.3.1 Decontamination Pad Specifications - The pad should be constructed in an area known or believed to be free of surface contamination. The pad should retain all decontamination fluids and site contaminants. If possible, locate the pad on a level, paved surface that is well drained. Pads located off pavement are subject to being shut down for extended periods following rain events due to standing water, equipment mired in mud, excessive mud on the pad, etc. The pavement also provides a firm support for heavy items such as augers. The pad should include a berm or wall that is 8 to 12 inches and completely surrounds the pad. Low cost walls can be constructed of unmortared concrete blocks, railroad ties, lumber, etc. The pad should include a small shallow sump dug in one corner of the pad. A hole can be made in the pavement, or a corner of the pad can extend beyond the paved area. The sump should be deep enough to contain the intake line of a pump. The pad should be lined with an impervious material with no seams within the pad. This material should either be easily relaced (disposable) or repairable. If a disposable liner is not chosen for the liner, a patch kit should be available to repair holes and tears. The area the liner is to cover should be swept or pressure washed prior to laying down the liner. Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above the ground to prevent equipment from being splashed. The sawhorses or rack legs should be cushioned with small pieces of lumber, rubber, etc., to avoid puncturing the liner.

E.3.2 Operation of the Decontamination Pad - When drilling wells, organic-free water should be generated on-site to provide a sufficient quantity to avoid serious project delays. Both organic-free water and solvent should be applied using Teflon® spray nozzles. Spent solvent is a hazardous waste. Unless specifically cited in the approved study plan, spent solvent should be kept separate from other decontamination fluids. The decontamination pad should be drained as needed to keep standing water to a minimum. Standing water easily splashes onto cleaned equipment. Cleaned equipment should be moved from the working area of the pad and completely wrapped to avoid splashing.

Gasoline powered equipment (pump, steam jenny, generator, etc.) should be kept downwind of the decontamination pad while it is running. Safety glasses with splash shields or goggles, and latex gloves should be worn during all cleaning operations. Solvent rinsing operations will be conducted in the open (never in a closed room). No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations. At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. No solvent rinsates will be placed in the pit. Solvent rinsates should be collected in separate containers for proper disposal. See Appendix D.7 of this document for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

E.4. Decontamination of Drilling Equipment

E.4.1 Introduction - Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. Tap water (potable) brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank of sufficient size so that drilling activities can proceed without having to stop and obtain additional water. A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam (200° F plus), with a soap compartment, should be obtained.

E.4.2 Preliminary Cleaning and Inspection - All drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (soap and high pressure hot water), or wire brushing. Sandblasting should be performed prior to arrival on-site, or well away from the decontamination pad and areas to be sampled. Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pull-downs, spindles, cathead, etc.) should be steam cleaned (soap and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other hazardous waste sites before being brought on-site. Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sandpaper can be used to remove the printing and/or writing. Most well material suppliers can supply materials without the printing and/or writing if specified when ordered. The drill rig and other equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed and all seals and gaskets are intact with no fluid leaks. PVC or plastic materials such as tremie tubes should be inspected. Items that cannot be cleaned are not appropriate and should be discarded.

E.4.3 Drill Rig Field Cleaning Procedure - Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chin pull-downs, spindles, cathead, etc.) should be steam cleaned (soap and high pressure hot water between boreholes.

E.4.4 Field Cleaning Procedure for Drilling Equipment - The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does not apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with soap) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing. Rinse thoroughly with tap water. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to insure that it stays in place.

E.5. Decontamination Procedures for Sampling Equipment

E.5.1 Trace Organic and Inorganic Constituent Sampling Equipment (Teflon® and Glass) - Wash equipment thoroughly with soap and hot tap water using a brush or scrub pad to remove any particulate matter or surface film. Rinse equipment thoroughly with hot tap water. Rinse equipment with 10 % nitric acid solution. Small and awkward equipment such as vacuum bottle inserts and well bailer ends may be soaked in the nitric acid solution instead of being rinsed with it. Fresh nitric acid solution should be prepared for each cleaning session. Rinse equipment thoroughly with analyte-free water. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a “tab” to allow for easy removal. Seal the foil wrapped equipment in plastic and label. Note: If the sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with the first step. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

E.5.2 Stainless Steel or Steel - Wash equipment thoroughly with soap and hot tap water using a brush or scrub pad to remove any particulate matter or surface film. Rinse equipment thoroughly with hot tap water. Rinse equipment thoroughly with analyte-free water. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours. Wrap equipment in one layer of aluminum foil. Roll edges of foil into a “tab” to allow for easy removal. Seal the foil wrapped equipment in plastic and label. Note: If the sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with the first step. In extreme cases, it may be necessary to steam-clean the field equipment before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

E.5.3 Cleaning Procedures for Tubing (Silastic® Pump Tubing) - The Silastic® pump tubing in the automatic samplers and peristaltic pumps should be replaced after each study. After installation, the exposed ends should be capped with clean, unused aluminum foil. Only new Teflon® should be used for the collection of samples for trace organic compounds or ICP analyses and should be pre-cleaned as follows:

(a) Teflon® tubing should be precut in 10, 15 or 25-foot lengths before cleaning.
(b) Rinse outside of tubing with solvent.
(c) Flush interior of tubing with solvent.
(d) Dry overnight in the drying oven.
(e) Coil and cap ends with aluminum foil.
(f) Wrap tubing in one layer of aluminum foil.
(g) Roll edges of foil into a "tab" to allow for easy removal.
(h) Seal the foil wrapped tubing in plastic and label.

E.5.4 Stainless Steel Tubing - Wash with soap and hot tap water using a long, narrow, bottle brush. Rinse equipment thoroughly with hot tap water. Rinse equipment thoroughly with analyte-free water. Rinse equipment thoroughly with solvent and allow to air dry for at least 24 hours. Cap ends with aluminum foil. Wrap tubing in one layer of aluminum foil. Roll edges of foil into a "tab" to allow for easy removal. Seal the foil wrapped tubing in plastic and date. Note: If the sampling equipment is used to collect samples that contain oil, grease, or other hard to remove materials, it may be necessary to rinse the equipment several times with pesticide-grade acetone, hexane, or petroleum ether to remove the materials before proceeding with the first step. In extreme cases, it may be necessary to steam-clean the field equipment before proceeding with Step 1. If the equipment cannot be cleaned utilizing these procedures, it should be discarded.

E.5.5 Glass Tubing - New glass tubing should be cleaned by rinsing thoroughly with solvent and air dried for at least 24 hours. Tubing should be wrapped completely with aluminum foil and sealed in plastic (one tube/pack) to prevent contamination during storage.

E.5.6 Cleaning Procedures for Miscellaneous Equipment:

(a) Well Sounders and Tapes - Wash with soap and tap water. Rinse with hot tap water. Rinse with analyte-free water. Allow to air dry overnight. Wrap equipment in aluminum foil, seal in plastic, and date.

(b) Fultz® Pump - Caution: to avoid damaging the Fultz® Pump never run pump when dry and never switch directly from forward to reverse mode without pausing in the "OFF" position. Pump a sufficient amount of hot soapy water through the hose to flush out any residual purge water. Using a brush or scrub pad, scrub the exterior of the contaminated hose and pump with hot soapy water. Rinse hose with analyte-free water and recoil onto the spool. Pump a sufficient amount of tap water through the hose to flush out soapy water (approximately one gallon). Pump a sufficient amount of analyte-free water through the hose to flush out the tap water, and then empty the pump and hose by placing pump in reverse. Do not allow pump to run dry. Rinse the pump housing and hose with analyte-free water. Place pump and reel in clean polyethylene bag or wrap in clean polyethylene film. Ensure that a complete set of new rotos, tow fuses and a set of cables are attached to the reel.

(c) Goulds® Pump - Caution: never plug the pump in while cleaning. Remove garden hose (if attached), and clean separately. Using a brush or scrub pad, scrub the exterior of the hose, electrical cord and pump with soap and tap water. Do not wet the electrical plug. Rinse with analyte-free water. Air dry. Place pump and hose in clean plastic bag and label.

(d) Redi-Flo® Pump - Caution: make sure that the controller is not plugged in and do not wet the controller. Wipe the controller box with a damp cloth. Remove any excess water immediately. Let the controller box dry completely. Caution: make sure the pump is not plugged in. Remove garden hose (if attached) and ball check valve. Clean these items separately. Using a brush or scrub pad, scrub the exterior of the electrical cord and pump with soap and tap water. Do not wet the electrical plug. Rinse with tap water. Rinse with analyte-free water. Completely air dry. Place equipment in clean plastic bag. Completely dismantle ball check valve. Check for wear and/or corrosion, and replace as needed. Using a brush, scrub all components with soap and hot tap water. Rinse with analyte-free water. Completely air dry. Reassemble the ball check valve and re-attach to Redi-Flo® pump head. Note: The analyte-free water within the Redi-Flo® pump head should be changed upon return from the field according to the manufacturer's instructions.

(e) Little Beaver® - The engine and power head should be cleaned with a power washer, steam jenny, or hand washed with a brush using soap to remove oil, grease, and hydraulic fluid from the exterior of the unit. Do not use degreasers. Rinse thoroughly with tap water. Auger flights and bits should be inspected thoroughly. If severe rust, corrosion, paint, or hardened grout is present, the equipment will require sandblasting prior to cleaning. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam-cleaning (high pressure hot water with soap) may be necessary to remove matter that is difficult to remove with the brush. Augers that are steam-cleaned should be placed on racks or saw horses at least 2 feet above the ground. Rinse thoroughly with tap water. Completely air dry. Remove and wrap with clean, unused plastic and return to storage.

(f) Field Analytical Equipment - Field instruments for in situ water analysis should be wiped with a clean, damp cloth. The probes on these instruments (pH, conductivity, DO, etc.) should be rinsed with analyte-free water and air-dried. Any desiccant in these instruments should be checked and replaced, if necessary, each time the equipment is cleaned.

(g) Ice Chests and Shipping Containers - Ice Chests and reusable containers should be washed with soap (interior and exterior) and rinsed with tap water and air-dried before storage. If in the opinion of the field investigators the container is severely contaminated with concentrated waste or other toxic material, it should be cleaned as thoroughly as possible, rendered unusable, and properly disposed.

(h) Garden Hose - Brush exterior with soap and tap water. Rinse with tap water. Flush interior with tap water until clear (minimum of one gallon). Completely air dry. Coil and place in clean plastic bag.

E.6. Preparation of Disposable Sample Containers

No disposable sample container (with the exception of the glass and plastic compositing containers) may be reused. All disposable sample containers will be stored in their original packing containers. When the packages of uncapped sample containers are opened, they should be placed in new plastic garbage bags and sealed to prevent contamination during storage.

E.6.1 **Plastic Containers used for "Classical" Parameters** - Plastic containers used for oxygen demand, nutrients, classical inorganics, and sulfides have no pre-cleaning requirement. However, only new containers may be used.

E.6.2 **Glass Bottles for Semi-Volatile GC/MS Analytes** - These procedures are to be used only if the supply of pre-cleaned, certified sample bottles is disrupted. If desired, pesticide-grade methylene chloride may be substituted for pesticide-grade isopropanol. In addition, 1:1nitric acid may be substituted for the 10% nitric acid solution. Wash bottles and jugs, Teflon® liners, and caps with hot tap water and soap. Rinse three times with tap water. Rinse with 10% nitric acid solution. Rinse three times with analyte-free water. Rinse bottles, jars, and liners (not caps) with solvent. Oven-dry bottles, jars, and liners at 125°C and allow to cool. Place liners in caps and closed containers. Store in contaminant-free area.

E.6.3 Glass Bottles for Volatile GC/MS and TOX Analyses - These procedures are to be used only if the supply of pre-cleaned, certified sample bottles is disrupted. Wash vials, bottles and jars, Teflon® liners and septa, and caps with hot tap water and laboratory detergent. Rinse all items with analyte free analyte-free water. Oven-dry at 125°C and allow to cool. Seal vials, bottles and jars with liners or septa as appropriate and cap. Store in a contaminant-free area.

E.6.4. **Plastic Bottles for ICP Analytes** - These procedures are to be used only if the supply of pre-cleaned, certified sample bottles is disrupted. Wash bottles and caps with hot tap water and soap. Rinse both with 10% nitric acid solution. Rinse three times with analyte-free water. Invert bottles and dry in contaminant-free environment. Cap bottles. Store in contaminant-free area.

Appendix F

Remediation Technologies

APPENDIX F - REMEDIATION TECHNOLOGIES

F.1 Appendix Outline

F.2. Introduction

This appendix addresses the various remediation technologies that are available to facilities and consultants when determining the most effective remedial technology for a site. The various remediation technologies were reviewed by representatives from the U.S. EPA, Department of Energy, Department of Defense, U.S. Department of the Interior, Department of the Navy, Department of the Air Force and the Department of the Army (collectively known as the Federal Remediation Technologies Roundtable). The technologies were evaluated to establish each technology's effectiveness with respect to the type of contaminant and the type of media impacted. The following discussion is a brief description of each of the technologies available to a facility today. Additional information regarding the following technologies can be obtained in the document "Remediation Technologies Screen Matrix and Reference Guide, Version 3.0, Federal Remediation Technologies Roundtable."

F.3. Soil, Sediment, and Sludge

F.3.1 In Situ Biological Treatment Technologies

(a) Bioventing is a new technology that stimulates the natural in situ biodegradation of any aerobically degradable compounds in soil by providing oxygen to excite soil microorganisms. Bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection into residual contamination in soil. In addition to degradation of adsorbed fuel residuals, volatile compounds are biodegraded as vapors move slowly through biologically active soil. Bioventing is a medium to long-term technology. Cleanup ranges from a few months to several years. Bioventing techniques have been successfully used to remediate soils contaminated by petroleum hydrocarbons, nonchlorinated solvents, some pesticides, wood preservatives, and other organic chemicals.

(b) Enhanced Bioremediation is a process in which indigenous or inoculated microorganisms (e.g.: fungi, bacteria, and other microbes) degrade (metabolize) organic contaminants found in soil and/or groundwater, converting them to innocuous end products. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials. In the presence of sufficient oxygen (aerobic conditions) and other nutrient elements, microorganism will ultimately convert many organic contaminants to carbon dioxide, water, and microbial cell mass. In the absence of oxygen (anaerobic conditions), the organic contaminants will be ultimately metabolized to methane, limited amounts of carbon dioxide, and trace amounts of hydrogen gas. Under sulfate-reduction conditions, sulfate is converted to sulfide or elemental sulfur. Under nitrate-reduction conditions, dinitrogen gas is ultimately produced. Enhance bioremediation of the soil typically involves the percolation or injection of groundwater or uncontaminated water mixed with nutrients and saturated with dissolved oxygen. Sometimes acclimated microorganisms (bioaugmentation) and/or another oxygen source such as hydrogen peroxide are also added. Infiltration gallery or spray irrigation is typically used for shallow contaminated soils, and injection wells are used for deeper contaminated soils. Bioremediation techniques have been successfully used to remediate soils, sludges, and groundwater contaminated with petroleum hydrocarbons, solvents, pesticides, wood preservatives, and other organic chemicals. Care should be taken when utilizing the aforementioned technology not to misinterpret the resulting analytical data. In many cases the resulting data following injection of bacteria, microbes, peroxide, or other additives may suggest that bioremediation is taking place, while in reality only dilution is occurring. It is for this reason that it is recommended that the resulting concentrations be presented to the Department in a mol/kg (mol/L for liquids) format in addition to either mg/kg or µg/kg (mg/L or µg/L for liquids).

(c) Land Treatment is a full-scale bioremediation technology in which contaminated soils, sediments, or sludges are turned over (i.e.: tilled) and allowed to interact with the soil and climate at the site. The waste, soil, climate, and biological activity interact dynamically as a system to degrade, transform, and immobilize waste constitutes. Wastes are periodically tilled to aerate the waste. Soil conditions are often controlled to optimize the rate of contaminant degradation. Conditions normally controlled include:

i. Moisture content (usually by irrigation or spraying).

ii. Aeration (by tilling the soil with a predetermined frequency).

iii. pH (buffered near neutral pH by adding crushed limestone or agricultural lime).

iv. Other amendments (e.g.; soil bulking agents, nutrients, etc.).

A Land Treatment site should be managed properly to prevent both on-site and off-site problems with groundwater, surface water, air, or food chain contamination. Adequate monitoring and environmental safeguards are required. Land Treatment is a medium- to long-term technology.

(d) Natural Attenuation in Soils - Natural biotransformation processes such as dilution, dispersion, volatilization, biodegradation, adsorption, and chemical reactions with soil materials can reduce contaminant concentrations to appropriate levels. Natural attenuation is not a “technology” per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option usually requires constant site modeling and evaluation of contaminant degradation rates, and pathways and predicting contaminant concentration at down-gradient receptor points. Natural attenuation is not considered a “no action” technology. Target contaminants for natural attenuation are VOCs, SVOCs, and fuel hydrocarbons.

(e) Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanism of phytoremediation includes enhanced rhizosphere biodegradation, phytoextraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization. Phytoremediation may be applicable for the remediation of metals, pesticides, solvents, explosives, crude oil, PAHs, and landfill leaches. Currently, trees are under investigation to determine their ability to remove organic contaminants from groundwater, translocate and transpiration, and possibly metabolize them either to CO^2 or plant tissue.

F.3.2 In Situ Physical/Chemical Treatment Technologies

(a) Electrokinetic Separation - The Electrokinetic Remediation (ER) process removes metals and organic contaminants from low permeability soil, mud, sludge, and marine dredging. ER uses electrochemical and electrokinetic processes to desorb, and remove metals and polar organics. This in situ soil processing technology is primarily a separation and removal technique for extracting contaminants from soils. Two approaches are taken during electrokinetic remediation: “Enhance Removal” and “Treatment without Removal.” “Enhance Removal” is achieved by electrokinetic transport of contaminants toward the polarized electrodes to concentrate the contaminants for subsequent removal and ex situ treatment. “Treatment without Removal” is achieved by electro-osmotic transport of contaminants through treatment zones placed between electrodes.

(b) Fracturing - Cracks are developed by fracturing beneath the surface in low permeability and over-consolidated sediments to open new passageways that increase the effectiveness of many in situ processes and enhance extraction efficiencies. Technologies commonly used in soil fracturing include pneumatic fracturing (PF), blast-enhanced fracturing, and Lasagna™ process. Fracturing is applicable to the complete range of contaminant groups with no particular target group. The technology is used primarily to fracture silts, clays, shale, and bedrock.

(c) Soil Flushing - In situ soil flushing is the extraction of contaminants from the soil with water or other suitable aqueous solutions. Water or water containing an additive to enhance contaminant solubility is applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone. Contaminants are leached into the groundwater, which is then extracted and treated. A type of soil flushing is cosolvent flushing known as Cosolvent Enhancement. Cosolvent flushing involves injecting a solvent mixture (e.g.: water plus a miscible organic solvent such as alcohol) into vadose zone, saturated zone, or both to extract organic contaminants. Cosolvent flushing can be applied to soils to dissolve either the source of contamination or the contaminant plume emanating from it. The cosolvent mixture is normally injected upgradient of the contaminated area, and the solvent with dissolved contaminants is extracted down-gradient and treated above ground. The duration of the soil flushing process is generally short- to medium-term. The target contaminant groups for soil flushing are inorganics including radioactive contaminants. The technology can be used to treat VOCs, SVOCs, fuels, and pesticides, but it may be less cost-effective than alternative technologies.

(d) Soil Vapor Extraction - Soil vapor extraction (SVE) is an in situ unsaturated (vadose) zone soil remediation technology in which a vacuum is applied through wells to create a pressure/concentration gradient that induces gas-phase volatiles to be removed from soil through extraction wells. This technology also is known as in situ soil venting, in situ volatilization, enhanced volatilization, or soil vacuum extraction. The duration of operation and maintenance for in situ SVE is typically medium- to long-term. The target contaminant groups for in situ SVE are VOCs and some fuels.

(e) In Situ Solidification/Stabilization - Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). This technology seeks to trap or immobilize contaminants within their "host" medium (*i.e.,* the soil, sand, and/or building materials that contain them), instead of removing them through chemical or physical treatment. Leachability testing is typically performed to measure the immobilization of contaminants. A specific type of solidification/stabilization technique is In Situ Vitrification (ISV). ISV uses an electric current to melt soil or other earthen materials at extremely high temperatures (1600°C to 2000°C or 2900°F to 3650°F) and thereby immobilize most inorganics and destroy organic pollutants by pyrolysis. The timeframe for in situ solidification/stabilization is short- to medium-term, while in situ ISV process is typically short-term. The target contaminant groups for this technology are generally inorganics (including radionuclides). The ISV process can destroy or remove organics and immobilize most inorganics.

F.3.3 In Situ Thermal Treatment Technologies

(a) Thermally Enhanced Soil Vapor Extraction - Thermally enhanced SVE is a full-scale technology that uses electrical resistance/electromagnetic/fiber optic/radio frequency heating, or hot-air/steam injection to increase the volatilization rate of semi-volatiles and facilitate extraction.

(b) Electrical resistance heating uses an electrical current to heat less permeable soils such as clays and fine-grained sediments so that water and contaminants trapped in these relatively conductive regions are vaporized and ready for vacuum extraction.

(c) Radio frequency heating (RFH) is an in situ process that uses electromagnetic energy to heat soil and enhance SVE.

(d) Another type of thermal enhanced soil vapor extraction technology is the injection of hot air or steam. Hot air or steam is injected below the contaminated zone to heat up contaminated soil. The heating enhances the release of contaminant from soil matrix. Some VOCs and SVOCs are stripped from the contaminated zone and brought to the surface through soil vapor extraction. Thermally enhanced SVE is normally a short- to medium-term technology.

F.3.4 Ex Situ Biological Treatment (assuming excavation)

(a) Biopile treatment is a full-scale technology in which excavated soils are mixed with soil amendments and placed on a treatment area that includes leachate collection systems and some form of aeration. It is used to reduce concentrations of petroleum constituents in excavated soils through the use of biodegradation. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation. Biopile is a short-term technology. Biopile treatment has been applied to treatment of nonhalogenated VOCs and fuel hydrocarbons. Halogenated VOCs, SVOCs and pesticides can also be treated, but the process effectiveness will vary.

(b) Composting is a controlled biological process by which organic contaminants (e.g.: PAHs) are converted by microorganisms (under aerobic and anaerobic conditions) to innocuous, stabilized byproducts. Contaminated soil is excavated and mixed with bulking agents and organic amendments such as wood chips, hay, manure, and vegetative (e.g.: potato) wastes. Proper amendment selection ensures adequate porosity and provides a balance of carbon and nitrogen to promote thermophilic, microbial activity. The composting process may be applied to soils and lagoon sediments contaminated with biodegradable organic compounds.

(c) Fungal Biodegradation refers to the degradation of a wide variety of organopollutants by using their lignin-degrading or wood-rotting enzyme system. White rot fungus has been tested under two different treatment configuration: in situ and bioreactor. White rot fungus has the ability to degrade and mineralize a number of organopollutants including the predominant conventional explosives TNT, RDX, and HMX. In addition, white rot fungus has the potential to degrade and mineralize other recalcitrant materials such as DDT, PAH, PCB, and PCP[2-4].

(d) Landfarming is a full-scale bioremediation technology that usually incorporates liners and other methods to control leaching of contaminants, which requires excavation and placement of contaminated soils, sediments, or sludges. Contaminated media is applied into lined beds and periodically turned over or tilled to aerate the waste. Landfarming has been proven most successful in treating petroleum hydrocarbons, diesel fuel, No.2 and No.6 fuel oils, JP-5, oily sludge, wood-preserving wastes (PCP and creosote), coking wastes, and certain pesticides.

(e) Slurry Phase Biological Treatment involves the controlled treatment of excavated soil in a bioreactor. Aqueous slurry is created by combining soil, sediment, or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed. Bioreactors are favored over in situ biological techniques for heterogeneous soils, low permeability soils, areas where underlying groundwater would be difficult to capture, or when faster treatment times are required. Slurry phased bioreactors are used primarily to treat nonhalogenated SVOCs and VOCs in excavated soils or dredged sediments. Ordnance compounds may also be treated. Slurry phased bioreactors containing cometabolites and specially adapted microorganisms are both used to treat halogenated VOCs and SVOCs, pesticides, and PCBs in excavated soils and dredge sediments.

F.3.5 Ex Situ Physical/Chemical Treatment (assuming excavation)

(a) Chemical Extraction includes the combination of waste contaminated soil and extractant in an extractor in order to dissolve the contaminants from the soil. The extracted solution is then placed in a separator, where the contaminants and extractant are separated for treatment and further use. There are two principal types of chemical extraction: acid extraction and solvent extraction. Acid extraction uses hydrochloric acid to extract heavy metal contaminants from soils. Solvent extraction is a common form of chemical extraction using an organic solvent. Organically bound metals can be extracted along with the target organic contaminants, thereby creating residuals with special handling requirements. Solvent extraction has been shown to be effective in treating sediments, sludges, and soils containing primarily organic contaminants such as PCBs, VOCs, halogenated solvents, and petroleum waste. Acid extraction is suitable to treat sediments, sludges, and soils contaminated by heavy metals.

(b) Chemical Reduction/Oxidation chemically converts hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorite, chlorine, and chlorine dioxide. The target contaminant group for chemical redox is inorganics.

(c) Dehalogenation Reagents are added to soils contaminated with halogenated organics. The dehalogenation process is achieved by either the replacement of the halogen molecules, or the decomposition and partial volatilization of the contaminants. The Base-Catalyzed Decomposition (BCD) process was developed by EPA's Risk Reduction Engineering Laboratory, in cooperation with the Naval Facilities Engineering Services Center to remediate soils and sediments contaminated with chlorinated organic compounds, especially PCBs, dioxins, and furans. Glycolate is a full scale technology in which an alkaline polyethylene glycol (APEG) reagent is used. The target contaminant groups for dehalogenation treatment are halogenated SVOCs and pesticides. APEG dehalogenation is one of the few processes available other than incineration that has been successfully field tested in treating PCBs. The BCD can also be used to treat halogenated VOCs but will generally be more expensive than other alternative technologies.

(d) Separation techniques concentrate contaminated solids through physical and chemical means (i.e.: Gravity Separation, Magnetic Separation, and Sieving/Physical Separation). These processes seek to detach contaminants from their medium (i.e.: the soil, sand, and/or binding materials that contain them). Gravity separation is a solid/liquid separation process, which relies on a density difference between the phases. Magnetic separation is used to extract slightly magnetic radioactive particles from host materials such as water, soil, or air. Sieving and physical separation processes use different size sieves and screens to effectively concentrate contaminants into smaller volumes. Physical separation is based on the fact the most organic and inorganic contaminants tend to bid, either chemically or physically, to the fine (i.e.: clay and silt) fraction of a soil. The target contaminant groups for ex situ separation processes are SVOCs, fuels, and inorganics (including radionuclides). Magnetic separation is specifically used on heavy metals, radionuclides, and magnetic radioactive particles, such as uranium and plutonium compounds.

(e) Soil Washing is a water-based process for scrubbing soils ex situ to remove contaminants. The wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals. The process removes contaminants from soils by dissolving or suspending them in the wash solution (which can be sustained by chemical manipulation of pH for a period of time) or by concentrating them into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing (similar to those techniques used in sand and gravel operations). Soil washing is generally considered a media transfer technology. The contaminated water generated from the soil washing is treated with the technology suitable for the contaminants. Soil washing systems incorporating most of the removal techniques offer the greatest promise for application to soils contaminated with a wide variety of heavy metal, radionuclides, and organic contaminants.

(f) Ex Situ Soil Vapor Extraction (SVE) is a full-scale technology in which soil is excavated and placed over a network of aboveground piping to which a vacuum is applied to encourage volatilization of organics. The target contaminant group for ex situ SVE is VOCs.

(g) Solar Detoxification is a process that destroys contaminants by photochemical and thermal reactions using the ultraviolet energy in sunlight. In this process, vacuum extraction is used to remove contaminants from soils. After condensation, contaminants are mixed with a semiconductor catalyst and fed through a reactor, which is illuminated by sunlight. This technology completely destroys the toxic compounds instead of simply removing or displacing them. The target contaminant groups for solar detoxification are VOCs, SVOCs, solvents, pesticides, and dyes. The process may also remove some heavy metals from water.

(h) Ex Situ Solidification/Stabilization - Contaminants are physically bound or enclosed with in a stabilized mass (solidification), or chemically reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). Ex situ solidification/stabilization (S/S) typically requires proper disposal of the resultant materials. Nine distinct innovated processes or groups of processes are bituminization, emulsified asphalt, modified sulfur cement, polyethylene extrusion, possolan/Portland cement, radioactive waste solidification, sludge stabilization, soluble phosphates, and vitrification/molten glass. The target contaminant group for ex situ S/S is inorganics, including radionuclides. Most S/S technologies have limited effectiveness against organics and pesticides, except vitrification which destroys most organic contaminants.

F.3.6 Ex Situ Thermal Treatment (assuming excavation)

(a) Hot Gas Decontamination involves raising the temperature of the contaminated equipment or material for a specified period of time. The gas effluent from the material is treated in an afterburner system to destroy all volatilized contaminants. This method is applicable for process equipment requiring decontamination for reuse. It is also applicable for explosive items, such as mines and shells, being demilitarized (after removal of the explosives) or scrap material contaminated with explosives. This method can also be used for buildings or structures associated with ammunition plants, arsenals, and depots involved in the manufacture, processing, loading, and storage of pyrotechnics, explosives, and propellants.

(b) Incineration is a process of destroying contaminants by heat. Various incineration methods used include: Circulating Bed Combustor, Fluidized Bed, Infrared Combustion, and Rotary Kiln. Target contaminant groups of incineration are VOCs, SVOCs, Fuels and Explosives.

(c) Open Burn/Open Detonation (OB/OD) operations are conducted to destroy excess, obsolete, or unserviceable munitions and energetic materials. In OB operations, explosives or munitions are destroyed by self-sustained combustion, which is ignited by an external source, such as flame, heat, or a detonation wave. In OD operations, detonatable explosives and munitions are destroyed by a detonation, which is generally initiated by the detonation of an energetic charge.

(d) Pyrolysis is formally defined as chemical decomposition induced in organic materials by heat in the absence of oxygen. Organic materials are transformed into gaseous components and a solid residue (coke) containing fixed carbon and ash. If volatile or semivolatile materials are present in the waste, thermal desorption will also occur. Conventional thermal treatment methods, such as rotary kiln, rotary hearth furnace, or fluidized bed furnace, are used for waste pyrolysis. Molten salt process may also be used for waste pyrolysis and involves the use of a molten salt incinerator that uses a molten, turbulent bed of salt, such as sodium carbonate, as a heat transfer and reaction/scrubbing medium to destroy hazardous materials. The target contaminant groups for pyrolysis are SVOCs and pesticides.

(e) Thermal Desorption is a physical separation process and is not designed to destroy organics. Wastes are heated to volatilize water and organic contaminants. A carrier gas or vacuum system transports volatilized water and organics to a gas treatment system. Two common thermal desorption designs are the rotary dryer and thermal screw. Three types of thermal desorption available are Direct Fired, Indirect Fired, and Indirect Heated. Based on operating temperature of the desorber, thermal desorption processes can be categorized into two groups: High Temperature Thermal Desorption (HTTD), and Low Temperature Thermal Desorption (LTTD). The target contaminants for HTTD systems are SVOCs, PAHs, PCBs, and pesticides; however, VOCs and fuels also may be treated. The target contaminants for LTTD systems are nonhalogenated VOCs and fuels.

F.3.7 Containment

(a) Landfill Capping is the most common form of remediation and is used for contaminant source control. The design of the landfill cap is site-specific and depends on the intended functions of the system. Landfill caps can range form a one-layer system of vegetated soil to a complex multi-layer system of soils and geosynthetics. Typical kinds of landfill caps include (1) Asphalt/Concrete Caps (most effective single-layer cap), RCRA Subtitle C Cap (used in RCRA Hazardous Waste applications), and RCRA Subtitle D Cap (for non-hazardous waste landfills).

(b) Landfill Cover Enhancements reduce or eliminate contaminant migration (*e.g.*, percolation). Water harvesting and vegetative cover are two ways for landfill cover enhancements. Water harvesting uses runoff enhancement to manage landfill site water balance. Vegetative cover reduces soil moisture via plant uptake and evapotranspiration.

F.3.8 Other Treatment by Excavation, Retrieval, and Off-Site Disposal - Contaminated material is removed and transported to permitted off-site treatment and/or disposal facilities. Some pretreatment of the contaminated media is usually required in order to meet land disposal restrictions.

F.4. Groundwater, Surface Water, and Leachate

F.4.1 In Situ Biological Treatment

(a) Co-Metabolic Process is an emerging application involving the injection of a dilute solution of primary substrate (e.g.: toluene, methane) into the contaminated groundwater zone to support the co-metabolic breakdown of targeted organic contaminants. The primary target contaminants for co-metabolism are the chlorinated solvents.

(b) Bioremediation is a process in which indigenous or inoculated microorganisms (i.e.: fungi, bacteria, and other microbes) degrade (metabolize) organic contaminants found in soil and/or groundwater. The rate of bioremediation of organic contaminants by microbes is enhanced by increasing the concentration of electron acceptors and nutrients in groundwater, surface water, and leachate. Oxygen is the main electron acceptor for aerobic bioremediation. Nitrate serves as an alternative electron acceptor under anoxic conditions. Oxygen enhancement can be achieved by either air sparging below the water table, or circulating hydrogen peroxide throughout the contaminated groundwater zone. Under anaerobic conditions, nitrate is circulated throughout the groundwater contamination zone to enhance bioremediation. Additionally, solid-phase peroxide products (e.g.: oxygen releasing compound (ORC)) can also be used for oxygen enhancement and to increase the rate of biodegradation. Target contaminants for enhanced biodegradation processes are nonhalogenated VOCs, nonhalogenated SVOCs, and fuels. Care should be taken when utilizing the aforementioned technology not to misinterpret the resulting analytical data. In many cases the resulting data following injection of bacteria, microbes, peroxide, or other additives may suggest that bioremediation is taking place, while in reality only dilution is occurring. It is for this reason that it is recommended that the resulting concentrations be presented to the Department in a mol/L (mol/kg for solids) format in addition to either mg/L or μg/L (mg/kg or μg/L for solids).

(c) Monitored Natural Attenuation (MNA) - Natural subsurface processes such as dilution, volatilization, biodegradation, dispersion; radioactive decay, sorption, and chemical or biological stabilization, transformation, or destruction of contaminants that are allowed to act without human intervention to reduce the mass, toxicity, mobility, volume, or contaminant concentrations to site-specific remediation objectives. The Department will review the long-term monitoring results of the MNA to ensure that reduction of contaminant concentrations are occurring at a reasonable rate that is comparable to the time frame generally offered by other more active methods and is consistent with meeting cleanup objectives. Furthermore, time frames for constituent degradation rates should be established and modified as necessary as sampling information is gathered and analyzed. When relying on natural attenuation processes for site remediation, those processes that degrade or destroy contaminants are required as opposed to processes that rely on dilution. It is this reason why the Department suggests that contaminant concentrations be reported in mol/L and also mg/L or μg/L to ensure that degradation is occurring as opposed to dilution. Also, the Department generally expects that MNA will only be appropriate for sites that have a low potential for contaminant migration.

The Department advocates using the most appropriate technology for a given site and does not consider MNA to be a “presumptive” or “default” remedy – it is merely one option that should be evaluated with other applicable remedies. The Department does not view MNA to be a “walk-away” approach meaning that both continued monitoring and evaluation are necessary. As with any other remedial alternative, MNA should be selected only where it meets all relevant remedy selection criteria, and where it will meet site remediation objectives within a time frame that is reasonable compared to that offered by other methods. In the majority of cases where MNA is proposed as a remedy, its use may be appropriate as one component of the total remedy, that is, either in conjunction with active remediation or as a follow-up measure. MNA should be used very cautiously as the sole remedy at contaminated sites. Furthermore, the availability of MNA as a potential remediation tool does not imply any lessening of the Department's longstanding commitment to pollution prevention. Waste minimization, pollution prevention programs, and minimal technical requirements to prevent and detect releases remain fundamental parts of the Department's waste management and remediation programs.

Due to the uncertainty associated with the potential effectiveness of MNA to meet remediation objectives that are protective of human health and the environment, the Department expects that source control and long-term performance monitoring will be fundamental components of any MNA remedy.

It is common practice in conducting remedial actions to focus on the most obvious contaminants of concern, but other contaminants may also be of significant concern in the context of MNA remedies. In general, since engineering controls are not used to control plume migration in an MNA remedy, decision makers need to ensure that MNA is appropriate to address all contaminants that represent an actual or potential threat to human health or the environment. Several examples are provided below to illustrate the need to assess both the obvious as well as the less obvious contaminants of concern when evaluating an MNA remedial option.

i. Mixtures of contaminants released into the environment often include some that may be amenable to MNA, and others that are not addressed sufficiently by natural attenuation processes to achieve remediation objectives. For example, benzene, toluene, ethylbenzene and xylenes (BTEX) associated with gasoline have been shown in many circumstances to be effectively remediated by natural attenuation processes. However, a common additive to gasoline (i.e.:, methyl tertiary-butyl ether [MTBE]) has been found to migrate large distances and threaten down-gradient water supplies at the same sites where the BTEX component of a plume has either stabilized or diminished due to natural attenuation. In general, compounds that tend not to degrade readily in the subsurface (e.g.: MTBE and 1,4-dioxane) and that represent an actual or potential threat should be assessed when evaluating the appropriateness of MNA remedies.

ii. Analyses of contaminated media often report chemicals that are identified with a high degree of certainty, as well as other chemicals labeled as "tentatively identified compounds" (TICs). It is often assumed that TICs will be addressed by remedial action along with the primary contaminants of concern. This may be a reasonable assumption for an active remediation system (e.g.: pump and treat) of contaminated groundwater, but might not be appropriate for an MNA remedy that is relying on natural processes to prevent contaminant migration. Where MNA is being proposed for sites with TICs, it may be prudent to identify the TICs and evaluate whether they too will be sufficiently mitigated by MNA.

iii. At some sites the same geochemical conditions and processes that lead to the biodegradation of chlorinated solvents and petroleum hydrocarbons can chemically transform naturally occurring minerals (e.g.: arsenic and manganese compounds) in the aquifer matrix to forms that are more mobile and/or more toxic than the original materials. A comprehensive assessment of an MNA remedial option should include evaluation of whether naturally occurring metals will become contaminants of concern.

Addressing the above concerns does not necessarily require sampling and analysis of extensive lists of parameters at every monitoring location in all situations. The location and number of samples collected and analyzed for this purpose should be determined on a site-specific basis to ensure adequate characterization and protection of human health and the environment.

Natural attenuation is not a "technology" per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option usually requires constant site modeling and evaluation of contaminant degradation rates, and pathways and predicting contaminant concentration at down-gradient receptor points. Natural attenuation is not considered a "no action" technology. Target contaminants for natural attenuation are VOCs, SVOCs, and fuel hydrocarbons.

(d) Phytoremediation is a set of processes that uses plants to remove, transfer, stabilize and destroy organic/inorganic contamination in groundwater, surface water, and leachate. The mechanisms of phytoremediation include: Enhanced Rhizosphere Biodegradation, Hydraulic Control, Phyto-degradation, and Phyto-volatilization. Phytoremediation can be used to clean up organic contaminants from surface water, groundwater, leachate, and municipal and industrial wastewater.

F.4.2 In Situ Physical/Chemical Treatment

(a) Aeration is the process by which the area of contact between water and air is increased, either by natural methods or by mechanical devices, for the purpose of promoting biological degradation. The target contaminant groups for aeration are SVOCs, pesticides, and fuels. VOCs can be stripped from wastewater and treated by aeration followed by off-gas treatments.

(b) Air Sparging is an in situ technology in which air is injected through a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes contaminants by volatilization. This injected air helps to flush the contaminants up into the unsaturated zone where a vapor extraction system is usually implemented to remove the generated vapor phase contamination. The target contaminant groups for air sparging are VOCs and fuels.

(c) Bioslurping is the adaptation and application of vacuum-enhanced dewatering technologies to remediate hydrocarbon-contaminated sites. Bioslurping utilizes elements of both, bioventing and free product recovery. Bioventing stimulates the aerobic bioremediation of hydrocarbon-contaminated soils. Vacuum enhanced free-product recovery extracts LNAPLs from the capillary fringe and the water table.

(d) Directional Wells - Drilling techniques are used to position wells horizontally, or at an angle to reach contaminants not accessible by direct vertical drilling. Directional drilling may be used to enhance other in situ or in-well technologies such as groundwater pumping, bioventing, SVE, soil flushing, and in-well air stripping. Directional well technology is applicable to the complete range of contaminant groups with no particular target group.

(e) Dual Phase Extraction (DPE), also known as multi-phase extraction, vacuum-enhanced extraction, or sometimes bioslurping, is a technology that uses a high vacuum system to remove various combinations of contaminated groundwater, separate-phase petroleum product, and hydrocarbon vapor for the subsurface. Extracted liquids and vapor are treated and collected for disposal, or re-injected to the subsurface (where permissible under applicable state laws). The target contaminant groups for DPE are VOCs and fuels (e.g.: LNAPLs).

(f) Fluid/Vapor Extraction systems consist of a high vacuum systems that are applied to simultaneously remove liquid and gas from low permeability or heterogeneous formations. Once the extracted water and vapor are brought to the surface, they can be treated separately. The target contaminant groups for Fluid/Vapor Extraction are VOCs and fuels.

(g) Hot Water or Steam Flushing/Stripping - Steam is forced into an aquifer through injection wells to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated zone where they are removed by vacuum extraction and then treated. Hot water or steam-based techniques include Contained Recovery of Oil Waste (CROW), Steam Injection and Vacuum Extraction (SIVE), In Situ Steam-Enhanced Extraction (ISEE), and Steam-Enhanced Recovery Process (SERP). Hot water or steam flushing/stripping is a pilot-scale technology. In situ biological treatment may follow the displacement and is continued until groundwater contaminant concentrations satisfy statutory requirements. The process can be used to remove large portions of oily waste accumulations and to retard downward and lateral migration of organic contaminants. The process is applicable to shallow and deep contaminated areas. The target contaminant groups for hot water or steam flushing/stripping are SVOCs and fuels.

(h) Hydrofracturing (enhancement) is a pilot-scale technology in which pressurized water is injected to increase the permeability of consolidated material or relatively impermeable unconsolidated material. Fissures created in the process are filled with a porous medium that can facilitate bioremediation and/or improved extraction efficiency. Hydrofracturing is applicable to a wide range of contaminant groups with no particular target group.

(i) In-Well Air Stripping is conducted in specially constructed wells with two separate well screens (upper and lower screens) known as Circulating Wells. Air is injected into the double screened well, lifting the water in the well and forcing it out the upper screen. Simultaneously, additional water is drawn in the lower screen. Once in the well, some of the VOCs in the contaminated groundwater are transferred from the dissolved phase to the vapor phase by air bubbles. The contaminated air rises in the well to the water surface where vapors are drawn off and treated by a soil vapor extraction system. Because groundwater is not pumped above ground, pumping cost and permitting issues are reduced and eliminated. In addition to groundwater treatment, Circulating Well systems can provide simultaneous vadose zone treatment in the form of bioventing or soil vapor extraction. The target contaminant groups for In Well Air Stripping are halogenated VOCs, SVOCs, and fuels.

(j) Passive/Reactive Treatment Walls - A permeable reactive wall is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants by employing such agents as zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, microbes, and others. The contaminants will be either degraded or retained by the barrier material. There are two types of passive reactive treatment walls, Funnel and Gate, and Iron Treatment Wall. Target contaminant groups for passive treatment walls are VOCs, SVOCs, and inorganics.

F.4.3 Ex Situ Biological Treatment (assuming pumping)

(a) Bioreactors - Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors. In suspended systems, such as activated sludge, contaminated groundwater is circulated in an aeration basin. In attached systems, such as rotating biological contractors and trickling filters, microorganisms are established on an inert support matrix. Bioreactors are used primarily to treat SVOCs, fuel hydrocarbons, and any biodegradable organic material. Bioreactors with cometabolites are used to treat PCBs, halogenated VOCs, and SVOCs in extracted groundwater.

(b) Constructed Wetlands - The constructed wetlands-based treatment technology uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate and remove metals, explosives, and other contaminants from influent waters. The process can use a filtration or degradation process. Constructed wetlands have most commonly been used in wastewater treatment for controlling organic matter; nutrients, such as nitrogen and phosphorous; and suspended sediment. The wetland process is also suitable for controlling trace metals, and other toxic materials.

(c) Adsorption/Absorption - In liquid adsorption, solutes concentrate at the surface of a sorbent, thereby reducing their concentration in the bulk liquid phase. Adsorption mechanisms are generally categorized as either physical adsorption, chemisorption, or electrostatic adsorption. The most common adsorbent is granulated activated carbon (GAC). Other natural and synthetic adsorbents include activated alumina, forage sponge, lignin adsorption, sorption clays, and synthetic resins. The target contaminant groups for adsorption/absorption processes are most organic contaminants and selected inorganic contaminants form liquid and gas streams.

(d) Air Stripping is a full-scale technology in which volatile organics are partitioned from groundwater by greatly increasing the surface area of the contaminated water exposed to air. Types of aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration. Air stripping is used to separate VOCs from water. It is ineffective for inorganic contaminants.

(e) Granulated Activated Carbon (GAC)/Liquid Phase Carbon Adsorption - Liquid phase carbon adsorption is a full-scale technology in which groundwater is pumped through one or more vessels containing activated carbon to which dissolved organic contaminants adsorb. Periodic replacement or regeneration of saturated carbon is required. The target contaminant groups for carbon adsorption are hydrocarbons, SVOCs, and explosives.

(f) Ion Exchange removes ions from the aqueous phase by the exchange of cations or anions between the contaminants and the exchange medium. Ion exchange materials may consist of resins made from synthetic organic materials that contain ionic functional groups to which exchangeable ions are attached. They also may be inorganic and natural polymeric materials. Ion exchange can remove dissolved metals and radionuclides form aqueous solutions. Other compounds that have been treated include nitrate, ammonia nitrogen, and silicate.

(g) Precipitation/Coagulation/Flocculation - This process transforms dissolved contaminants into insoluble solids, facilitating the contaminant’s subsequent removal from the liquid phase by sedimentation or filtration. The process usually uses pH adjustment, addition of a chemical precipitant, and flocculation. Precipitation is used mainly to convert dissolved ionic species into solid-phase particulates that can be removed from the aqueous phase by coagulation and filtration. Remedial application of this technology usually involves removal of dissolved toxic metals and radionuclides.

(h) Separation processes seek to detach contaminants from their medium (*i.e.,* groundwater and/or binding material that contain them). Ex situ separation of the waste stream can be performed by many processes (i.e.: distillation, filtration, ultrafiltration, microfiltration, freeze crystallization, membrane pervaporation, and reverse osmosis. The ex situ separation process is used mainly as a pre-treatment or post-treatment process to remove contaminants from wastewater. It can be applied to aqueous waste streams such as groundwater, lagoons, leachate, and rinse water. The target contaminant groups for ex situ separation processes are VOCs, SVOCs, pesticides, and suspended particles.

(i) Sprinkler Irrigation is a relatively simple treatment technology used to volatilize VOCs from contaminated wastewater. The process involves the pressurized distribution of VOC-laden water through a standard sprinkler irrigation system. Sprinkler irrigation transfers VOCs from the dissolved aqueous phase to the vapor phase, whereby the VOCs are released directly to the atmosphere. Another aerating wastewater treatment is the trickling filter. The trickling filter consists of a bed of highly permeable media, a water distributor, and an underdrain system. Wastewater is distributed over the tip of the filter bed through which wastewater is trickled. The microorganisms attached to the filter medium degrade the organic contaminants in wastewater. Sprinkler irrigation can be utilized for any contaminant that readily transfers from the dissolved phase to the vapor phase (VOCs). The target contaminant groups for trickling filters are VOCs, SVOCs, fuels, explosives, and pesticides.

(j) Ultraviolet (UV) Oxidation, ozone, and/or hydrogen peroxide are used to destroy organic contaminants as water flows into a treatment tank. If ozone is used as the oxidizer, an ozone destruction unit is used to treat collected off gases from the treatment tank and downstream units where ozone gas may collect or escape. UV Photolysis is the process by which chemical bonds of the contaminants are broken under the influence of UV light. Practically any organic contaminant that is reactive with the hydroxyl radical can potentially be treated. A wide variety of organic and explosive contaminants are susceptible to destruction by UV/oxidation, including petroleum hydrocarbons; chlorinated hydrocarbons used as industrial solvents and cleaners; and ordnance compounds.

F.4.4 Containment

(a) Groundwater Pumping is a component of many pump-and-treat processes, which are some of the most commonly used groundwater remediation technologies at contaminated sites. Possible objectives of groundwater pumping include removal of dissolved contaminants form the subsurface, and containment of contaminated groundwater to prevent migration. The application of surfactant miceles or steam to the groundwater can facilitate the groundwater pumping process by increasing the mobility and solubility of the contaminants sorbed to the soil matrix. Pump drawdown nonaqueous-phase liquid (NAPL) recovery systems are designed to pump NAPL and groundwater from recovery wells or trenches. Pumping removes water and lowers the water table near the extraction well to create a cone of depression.

(b) Slurry Walls - These subsurface barriers consist of vertically excavated trenches filled with slurry. The slurry, usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse and retards groundwater flow. Slurry walls are used to contain contaminated groundwater, divert contaminated groundwater from the drinking water intake, divert uncontaminated groundwater flow, and/or provide a barrier for the groundwater treatment system.

Appendix G

Tables

APPENDIX G - TABLES

Table 1 - Recommended Containers, Holding Times, & Preservatives

The following tables summarize the amount of sample required, typical containers, preservative (if any) and holding times for many analysis, by media.

Soil and Sediment – *Organic Compounds*				
Analysis	Amt.[1]	Container Type[2]	Preservative[3]	Holding Time[4]
Dioxin/Dibenzofurans	8 oz.	G	ice	30
Extractable Organic Compounds/ pesticides/PCBs	8 oz.	G	ice	14
Extractable Organic Compounds - TCLP	8 oz.	G	ice	14
Organic Halide	8 oz.	G	ice	28
VOC ≤ 200 µg/kg (water suspension)	120 ml.	G/S	ice	48 hours
VOC ≤ 200 µg/kg	15 g.	E	ice	48 hours
VOC ≤ 200 µg/kg(water suspension)	120 ml.	G/S	$NaHSO_4$ (pH<2), ice	14
VOC ≥ 200 µg/kg	120 ml.	G/S	CH_3OH, ice	14
VOC ≥ 200 µg/kg	15 g.	E	ice	48 hours
VOC ≥ 200 µg/kg	2 oz.	G/S	ice	48 hours
VOC – TCLP Analysis	2 oz.	G	ice	14

Soil and Sediment – *Inorganic Compounds*

Analysis	Amt.[1]	Container Type[2]	Preservative[3]	Holding Time[4]
Chloride	8 oz.	G	NA	NS
Chromium – hexavalent	8 oz.	G	ice	30
Cyanide	8 oz.	G	ice	NS
COD	8 oz.	G	ice	NS
Fluoride	8 oz.	G	NA	NS
Grain size	8 oz.	G	NA	NS
Mercury	8 oz.	G	ice	28
Mercury – TCLP	8 oz.	G	NA	28
Metals	8 oz.	G	ice	180
Metals – TCLP	8 oz.	G	NA	180
Metals – EP	8 oz.	G	NA	180
Nitrate	8 oz.	G	ice	NS
Nitrite	8 oz.	G	ice	NS
Nutrients (ammonia, TKN, NO2, NO3, N, total phosphate	8 oz.	G	ice	NS
pH	8 oz.	G	NA	NS
Sulfates	8 oz.	G	NA	NS
Sulfides	8 oz.	G	ice	NS
TOC	8 oz.	G	ice	NS

Water and Waste Water - *Biological*

Analysis	Amt.[1]	Container Type[2]	Preservative[3]	Holding Time[4]
Bacteriological	150 ml.	P, G, W	ice	6 hours
Toxicity, acute	1 gal.	C	ice	36 hours
Toxicity, chronic	1 gal.	C	ice	36 hours

Water and Waste Water – *Organic Compounds*

Analysis	Amt.[1]	Container Type (2)	Preservative[3]	Holding Time[4]
Alcohol – Percent	1 gal.	G/A	ice	NS
Dioxin/Dibenzofurans	2 L.	L/A	ice (0 - 4 C)	365
Dioxin/Dibenzofurans – residual chloride	2 L.	L/A	ice (0 - 4 C) 80 mg. sodium thiosulfate /L	365
Methane/Ethane/Ethene	120 ml.	G/S	HCL (pH<2), ice	14
Extractable Organic Compounds/ pesticides/ PCBs	1 gal.	G/A	ice	7
Extractable Organic Compounds/ pesticides/ PCBs – residual chlorine present	1 gal.	G/A	3 ml. of 10% sodium thiosulfate per gallon	7
Extractable Organic Compounds	1 gal.	G/A	ice	14
Organic Halide	1 L.	G/A	H_2SO_4 (pH<2), ice	28
Phenols	1 L.	G/A	H_2 SO_4 (pH<2), ice	28
Volatile Organic Compounds	120 ml.	G/S	ice	7
Volatile Organic Compounds	120 ml.	G/S	HCL (ph<2), ice	14
Volatile Organic Compounds	120 ml.	G/S	$NaHSO_4$ (pH<2), ice	14
Volatile Organic Compounds – residual chlorine present	120 ml.	G/S	HCL (pH<2), ice	14
Volatile Organic Compounds - TCLP	120 ml.	G/S	ice	14

Water and Waste Water – *Inorganic Compounds*				
Analysis	Amt.[1]	Container Type[2]	Preservative[3]	Holding Time[4]
Ammonia	1 L.	P	H_2SO_4 (pH<2), ice	28
Alkalinity	1 L.	P	ice	14
BOD5	2 L.	P	ice	2
Bromide	1 L.	P	ice	28
Chlorine – Residual	500 ml.	P	NA	ASAP
Chloride	1 L.	P	NA	28
Chromium - hexavalent	1 L.	P	ice	24hours
COD	1 L.	P	H_2SO_4 (pH<2), ice	28
Color	1 gal.	G/A	ice	2
Conductivity	500 ml.	P	ice	28
Cyanide	1 L.	P	NaOH (pH>12), ice	14
Cyanide – Residual chlorine	1 L.	P	see footnote 6	14
DOC	1 L.	P	$NaHSO_4$ (pH<2), ice	28
Fluorine	1 L.	P	NA	28
Hardness	1 L.	P	HNO_3 (pH<2)	180
Iron (Fe^{2+})	1 L.	P	NA	ASAP
Mercury	1 L.	P	HNO_3 (pH<2)	28
Mercury – TCLP	1 L.	P	NA	28
Metals	1 L.	P	HNO_3 (pH<2)	180
Metals – TCLP	1 L.	P	NA	180
Metals – EP	1 L.	P	NA	180
Nitrate	2 L.	P	ice	2
Nitrite	1 L.	P	ice	2
Nutrients (Ammonia, TKN, NO2, NO3, -N, total phosphorous)	2 L.	P	H_2SO_4 (pH<2), ice	28

Water and Waste Water – *Inorganic Compounds (continued)*				
Analysis	Amt.[1]	Container Type[2]	Preservative[3]	Holding Time[4]
Oil and Grease	1 L.	P	H_2SO_4 (pH<2), ice	28
Oxygen – dissolved	40 ml.	G	NA	ASAP
pH	500 ml.	P	NA	ASAP
Phenols	1 L.	P	H_2SO_4 (pH<2), ice	28
Phosphate – ortho	1L.	P	ice	2
Phosphate – dissolved	1L.	P	H_2SO_4 (pH<2), ice	28
Solids Series	2 L.	P	ice	7
Solids – Settleable	2 L	P	ice	2
Sulfates	1 L	P	ice	28
Sulfides	1 L.	P	2 ml zinc acetate, NaOH (pH>9), ice	7
Temperature	500 ml.	P	none	ASAP
TOC	1 L.	P	H_2SO_4 (pH<2), ice	NS
Turbidity	500 ml.	P	ice	2

Waste – *Organic Compounds*				
Analysis	Amt.[1]	Container Type[2]	Preservative[3]	Holding Time[4]
Alcohol – Present				
Dioxin/Dibenzofurans				
Extractable Organic Compounds/pesticides/PCBs				
Extrctable Organic Compounds – TCLP				
VOC ≤ 200 µg/kg				
VOC ≤ 200 µg/kg				
VOC ≥ 200 µg/kg				
Volatile Organic Compounds – TCLP				
Waste – *Inorganic Compounds*				
Analysis	Amt.[1]	Container Type[2]	Preservative[3]	Holding Time[4]
Ash Content	8 oz.	G	NA	NS
BTU Content	8 oz.	G	NA	NS
Chromium – hexavalent	8 oz.	G	NA	NS
Cyanide	8 oz.	G	NA	NS
Dermal Corrosion	8 oz.	G	NA	NS
Flashpoint	8 oz.	G	NA	NS
Mercury	8 oz.	G	NA	180
Mercury – TCLP	8 oz.	G	NA	NS
Metals	8 oz.	G	NA	28
Metals – TCLP	8 oz.	G	NA	NS
Metals – EP	8 oz.	G	NA	28
pH	8 oz.	G	NA	NS
Sulfides	8 oz.	G	NA	NS

Footnotes:

1. Amount - The amounts listed must be considered approximate requirements that are appropriate for most media. If a particular media to be sampled is very light, more sample may be required to obtain the necessary mass for the analysis.

2. Container Type:

G = Glass
P = Polyethylene
E = Encore™
C = Cubitainer
S = Septum Seal
A = Amber
W = Whirl-Pak™

3.	ice:	Sufficient ice must be placed in the shipping/transport container to ensure that ice is still present when the samples are received at the laboratory
	NaHSO4:	The proper amount of NaHSO4 (Sodium Bisulfate) is added to the sample container at the laboratory prior to sampling.
	CH3OH:	The proper amount of CH3OH (Methanol) is added to the sample container at the laboratory prior to sampling.
	HCl:	HCl (Hydrochloric Acid) used as a preservative must be present at concentrations of 0.04% or less by weight (pH about 1.96 or greater), as specified in 40 CFR 136.3, Table II, footnote 3. The proper amount of HCl is added to the sample container at the laboratory prior to sampling.
	H2SO4:	H2SO4 (Sulfuric Acid) used as a preservative must be present at concentrations of 0.35% or less by weight (pH about 1.15 or greater), as specified in 40 CFR 136.3, Table II, footnote 3. Approximately 5 ml. of the laboratory prepared preservative is added to the sample.
	NaOH:	NaOH (Sodium Hydroxide) used as a preservative must be present at concentrations of 0.080% or less by weight (pH about 12.30 or less), as specified in 40 CFR 136.3, Table II, footnote 3. Four tablets are added to the sample after collection.
	HNO3:	HNO3 (Nitric Acid) used as a preservative must be present at concentrations of 0.15% or less by weight (pH about 1.62 or greater), as specified in 40 CFR 136.3, Table II, footnote 3. Approximately 5 ml. of the laboratory prepared preservative is added to the sample.
	NA:	Not Applicable. No sample preservation is required

4.Holding Time – Holding time is stated in days unless marked otherwise. A holding time of ASAP indicates the sample is to be analyzed within 15 minutes. A holding time of NS indicates that no holding time is specified in the analytical method.

5. Collect sample in 8 oz. glass container containing ascorbic acid solution prepared by the laboratory. Gently mix sample and transfer to sample containers prepared by the laboratory with the proper amount of HCl.

6. Use ascorbic acid only if the sample contains residual chlorine. To test for residual chlorine, place a drop of sample on potassium iodide-starch test paper. If the test paper turns blue, residual chlorine is present. Add a few crystals of ascorbic acid and re-test until the test paper no longer turns blue. Add an additional 0.6 gram of ascorbic acid for each liter of sample.

Table 2 - Disposal of IDW

Type	Hazardous	Non-Hazardous
PPE – disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to the Field Equipment Center (FEC) for disposal in dumpster.
PPE – nondisposable	Decontaminate as per Appendix E, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per Appendix E.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	NA
Soil Cuttings	Containerize in 55-gallon drum with tightfitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave onsite with permission of site operator, otherwise arrange with site manager for testing and disposal.
Groundwater	Containerize in 55-gallon drum with tightfitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave onsite with permission of site operator, otherwise arrange with site manager for testing and disposal.
Decontamination Water	Containerize in 55-gallon drum with tightfitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	Containerize in 55-gallon drum with tight-fitting lid. Identify and leave onsite with permission of site operator, otherwise arrange with site manager for testing and disposal.
Disposable Equipment	Containerize in 55-gallon	Containerize in 55-gallon

	drum or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with WMD site manager for testing and disposal.	drum or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with site manager for testing and disposal.
Trash	NA	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

Appendix H

References

APPENDIX H - REFERENCES

United States Protection Agency, 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells; United States Environmental Protection Agency, Office of Research and Development, EPA/600/4-89/034, 221pp.

ADEM Admin. Code R. 335-13.

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Region 4 USEPA

Operating Procedure, Groundwater Level and Well Depth Measurement

January 2013

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Groundwater Level and Well Depth Measurement**	
Effective Date: January 29, 2013	**Number:** SESDPROC-105-R2
Authors	
Name: Brian Striggow Title: Environmental Engineer Signature:	Date: 1-22-13
Approvals	
Name: Danny France Title: Chief, Enforcement and Investigations Branch Signature:	Date: 1-22-13
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature:	Date: 1/22/13

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-105-R2, *Groundwater Level and Well Depth Measurement*, replaces SESDPROC-105-R1 **General:** Corrected any typographical, grammatical, and/or editorial errors. **Title Page:** Changed the Author from Don Hunter to Brian Striggow Changed the EIB Chief from Antonio Quinones to Danny France. Changed the FQM from Laura Ackerman to Bobby Lewis. **Revision History:** In the 3rd sentence, changed Field Quality Manager to Document Control Coordinator. **Section 1.2:** Added the following statement: Mention of trade names or commercial products does not constitute endorsement or recommendation for use. **Section 1.3:** Omitted reference to the H: drive. Changed Field Quality Manager to Document Control Coordinator. **Section 1.4:** Updated references. **Section 2, 1st bullet:** Replaced references to "calibration" of groundwater level measuring devices to "verification" of such devices. In the 1st sentence, updated the language to reflect that devices used to measure groundwater levels will be verified annually against a NIST-traceable measuring tape instead of an Invar® steel surveyor's chain. In the 2nd sentence, added "…with an allowable error of 0.03 feet in the first 30 feet." Added the last sentence (reference to SESDFORM-043, *Well Sounder Function Check and Verification* form). **Section 3.1, 1st paragraph, last sentence:** Rewrote the sentence for clarity. Added the 4th paragraph regarding equilibration of water levels. **Added new Section 3.3,** *Special Considerations for Water Level Measurements at Low Groundwater Gradient.* Re-numbered following sub-sections. **Section 3.4:** Added the 5th sentence and the last sentence.	January 29, 2013

SESDPROC-105-R1, *Groundwater Level and Well Depth Measurement*, replaces SESDPROC-105-R0 **General** Updated referenced procedures due to changes in title names and/or to reflect most recent version. **Title Page** Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch. **Section 1.3** Updated information to reflect that procedure is located on the H: drive of the LAN. **Section 1.4** Alphabetized and revised the referencing style for consistency.	November 1, 2007
SESDPROC-105-R0, Groundwater Level and Well Depth Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when determining water levels and depths of wells.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators to measure water levels and depths of wells. On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for water level or depth determination, the variant procedure(s) will be documented in the field logbook and the subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network. The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when measuring water levels in wells and determining their depths. Refer to the SESD Safety, Health and

Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when measuring water levels and depths of wells:

- Special care must be taken to minimize the risk of cross-contamination between wells when conducting water level and depth measurements. This is accomplished primarily by decontaminating the sounders or other measuring devices between wells, according to SESD Operating Procedure for Field Equipment Cleaning and Decontamination, (SESDPROC-205) and maintaining the sounders in clean environment while in transit between wells.
- Water levels and well depths measured according to these procedures should be recorded in a bound logbook dedicated to the project as per SESD Operating Procedure for Logbooks (SESDPROC-010). Serial numbers, property numbers or other unique identification for the water level indicator or sounder must also be recorded.

2 Quality Control Issues

There are several specific quality control issues pertinent to conducting water level and depth measurements at wells. These are:

- Devices used to measure groundwater levels will be verified annually against a National Institute of Standards and Technology (NIST) traceable measuring tape.. These devices should check to within 0.01 feet per 10 feet of length with an allowable error of 0.03 feet in the first 30 feet. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. All verification and maintenance data should be documented electronically or recorded in a logbook maintained at the Field Equipment Center (FEC) as per the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). The functional check and tape length verification should be performed according to the instructions included in SESDFORM-043, *Well Sounder Function Check and Verification,* which also includes the form for recording the required information.
- These devices should be decontaminated according to the procedures specified in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) prior to use at the next well.

3 Water Level and Depth Measurement Procedures

3.1 General

The measurement of the groundwater level in a well is frequently conducted in conjunction with ground water sampling to determine the “free” water surface. This potentiometric surface measurement can be used to establish ground water direction and gradients. Groundwater level and well depth measurements are needed to determine the volume of water or drawdown in the well casing for proper purging.

All groundwater level and well depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing and note this procedure in the field logbook.

To be useful for establishing groundwater gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. For an isolated group of wells, it is acceptable to use an arbitrary datum common to all wells in that group, if necessary.

Water levels should be allowed to equilibrate prior to measurement after removing sealing caps. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.

3.2 Specific Groundwater Level Measurement Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods. Method accuracies are noted for each of the specific methods described below.

- Electronic Water Level Indicators – These types of instruments consist of a spool of dual conductor wire, a probe attached to the end and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or audible buzzer attached to the spool will signal contact. Penlight or 9-volt batteries are normally used as a power source. Measurements should be made and recorded to the nearest 0.01 foot.

- Other Methods – There are other types of water level indicators and recorders available on the market, such as weighted steel tape, chalked tape, sliding float method, air line pressure method and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells.

Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot should not be used.

3.3 Special Considerations for Water Level Measurements at Sites with Shallow Groundwater Gradient

Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps and the same sounder should be used for all measurements, if possible. The sounding activity should be coordinated to allow all wells to be sounded within the minimum possible time. This is particularly important in areas with potential tidal influences.

3.4 Total Well Depth Measurement Techniques

The well sounder, weighted tape or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well and sediment in the bottom of the well can also make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements. The operator may find it easier to allow the weight to touch bottom and then detect the ‘tug’ on the tape while lifting the weight off the well bottom. All total depth measurements must be made and recorded to the nearest 0.1 foot. As a cautionary note, when measuring well depths with the electronic water level indicators, the person performing the measurement must measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth. This is necessary because the tape distance markings are referenced to the electrodes, rather than the end of the probe. For electronic sounders maintained at the SESD FEC, the sounder reel will be marked with the appropriate additional length identified as the ‘TD adder’.

3.5 Equipment Available

The following equipment is available for ground water level and total depth measurements:

- Weighted steel measuring tapes
- Electronic water level indicators

Region 4 USEPA

Operating Procedure, Groundwater Sampling

March 2013

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Groundwater Sampling**

Effective Date: March 6, 2013

Number: SESDPROC-301-R3

Authors

Name: Jonathan Vail
Title: Environmental Scientist, Regional Expert
Signature: J Vail
Date: 3/4/2013

Approvals

Name: Danny France
Title: Chief, Enforcement and Investigations Branch
Signature:
Date: 3/4/13

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 3/4/13

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-301-R3, Groundwater Sampling, replaces SESDPROC-301-R2. **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Changed author from Donald Hunter to Jonathan Vail. Changed Enforcement and Investigations Branch Chief from Archie Lee to Danny France. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2.3**: Item 4 was revised to reflect practice of using individual single-use preservative vials instead of preservatives prepared by ASB.	**March 6, 2013**
SESDPROC-301-R2, Groundwater Sampling, replaces SESDPROC-301-R1.	**October 28, 2011**
SESDPROC-301-R1, Groundwater Sampling, replaces SESDPROC-301-R0.	**November 1, 2007**
SESDPROC-301-R0, Groundwater Sampling, Original Issue	**February 05, 2007**

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting groundwater samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion that SESD field personnel determine that any of the procedures described are either inappropriate, inadequate or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Columbia Analytical Services, Lab Science News, Passive Diffusion Devices & Polyethylene Diffusion Bag (PDB) Samplers.

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Puls, Robert W., and Michael J. Barcelona. 1989. Filtration of Ground Water Samples for Metals Analysis. Hazardous Waste and Hazardous Materials 6(4), pp.385-393.

Puls, Robert W., Don A. Clark, and Bert Bledsoe. 1992. Metals in Ground Water: Sampling Artifacts and Reproducibility. Hazardous Waste and Hazardous Materials 9(2), pp. 149-162.

SESD Guidance Document, Design and Installation of Monitoring Wells, SESDGUID-001, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Groundwater Level and Well Depth Measurement, SESDPROC-105, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDROC-202, Most Recent Version

SESD Operating Procedure for Pump Operation, SESDPROC-203, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

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US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.

- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and placed in the project files.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Groundwater samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas unpreserved samples have only a seven-day holding time. In the great majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high amount of dissolved limestone, i.e., is highly calcareous, there will most likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

Samples for VOC analysis must be collected using either stainless steel or Teflon® equipment, such as:

- Bailers must be constructed of stainless steel or Teflon®
- RediFlo2® submersible pumps used for sampling should be equipped with Teflon® sample delivery tubing
- Peristaltic pump/vacuum jug assemblies should be outfitted with Teflon® tubing from the water column to the transfer cap, which should also be constructed of Teflon®

2.2 Special Precautions for Trace Contaminant Groundwater Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

- Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, verified certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer, either from the pour stream of an up-turned bailer or from the stream from a bottom-emptying device. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.

2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.

3. Place the sample into appropriate, labeled containers. Samples collected for VOC, acidity and alkalinity analysis must not have any headspace. All other sample containers must be filled with an allowance for ullage.

4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by ASB personnel prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM).

2.4 Quality Control

If possible, a control sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same water-bearing formation. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers or other sampling equipment.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Procedure for Sample and Evidence Management, SESDPROC-005.

3 Groundwater Sampling Methods – Purging

3.1 General

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of actual aquifer conditions. In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed during purging and, in the case of permanent monitoring wells, observe and record the volume of water removed.

There are several purging strategies that may be used, depending on specific conditions encountered for given well sampling situations. When a specific well is characterized, based on the field investigators experience and knowledge, as having fairly typical water levels, depths and purge volumes, as determined according to the procedures in Section 3.2.1, below, SESD will normally use the multiple volume purging procedures and equipment described in Sections 3.2.1 and 3.3 of this procedure for purging the well.

When the traditional multiple volume purge method is considered and it is determined that excessive quantities of IDW would be generated using this method, it may be appropriate, under very limited and specific circumstances, to use an alternate method that reduces the time and amount of purge water to be removed prior to sampling the well. The field project leader will select the alternate method only after careful consideration of the conditions presented by the well and the impact these conditions have on all aspects of the sampling event (time required to sample, quantities of IDW requiring management, etc.).

The alternate purge procedures or sampling strategies available are the “Tubing-in-Screened Interval” method and the MicroPurge or No-Purge methods. These are described and discussed in Sections 3.2.2 and 4.5 of this operating procedure, respectively.

3.2 Purging Methods and Strategies

3.2.1 Traditional Multiple Volume Purge

3.2.1.1 Purging and Purge Adequacy

3.2.1.1.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. Specific methodology for obtaining these measurements is found in SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105).

Once this information is obtained, the volume of water to be purged can be determined using one of several methods. One is the equation:

$V = 0.041\ d^2h$

Where: h = depth of water in feet
d = diameter of well in inches
V = volume of water in gallons

Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, similar to that in Table 3.2.1. The water level is subtracted from the total depth, providing the length of the water column. This length is multiplied by the appropriate factor in the Table 3.2.1, corresponding to either the single well volume or the triple well volume, to determine both the single well volume and triple well volumes, in gallons, for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

TABLE 3.2.1: WELL CASING DIAMETER VOLUME FACTORS

Casing Diameter (inches)	Gallons/ft, One Water Column	Gallons/ft, Three Water Columns
1	0.04	0.12
2	0.16	0.48
3	0.37	1.11
4	0.65	1.98
5	1.02	3.06
6	1.47	4.41
7	1.99	5.97
8	2.61	7.83
9	3.30	9.90
10	4.08	12.24
11	4.93	14.79
12	5.87	17.61

With respect to volume, an adequate purge is normally achieved when three to five well volumes have been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate multiplication of that volume, i.e., a minimum three well volumes, clearly identified as a purge volume goal.

3.2.1.1.2 Chemical Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Primary Drinking Water Standard of 5 NTUs). Although 10 NTUs is normally considered the minimum goal for most ground water sampling objectives, lower turbidity has been shown to be easily achievable in most situations and reasonable attempts should be made to achieve these lower levels. (Note: Because groundwater temperature is subject to rapid changes when collected for parameter measurement, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from the list of parameters used for stability determination. Even though temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters during well purging, as it may be needed to interpret other chemical parameter results in some situations.)

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than approximately 5 percent. Other parameters, such as dissolved oxygen (DO), may also be used as a purge adequacy parameter. Normal goals for DO are 0.2 mg/L or 10% saturation, whichever is greater. DO measurements must be conducted using either a flow-through cell or an over-topping cell to minimize or reduce any oxygenation of the sample during measurement. Oxidation Reduction Potential (ORP) should not be used as a purge stabilization parameter but may be measured during purging to obtain the measurement of record for ORP for the sampling event.

There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes, for example, may be sufficient. See the SESD Operating Procedures for Field pH Measurement (SESDPROC-100), Field Specific Conductance Measurement (SESDPROC-101), Field Temperature Measurement (SESDPROC-102), Field Turbidity Measurement (SESDPROC-103), Field Measurement of Dissolved Oxygen (SESDPROC-106) and Field Measurement of Oxidation-Reduction Potential (SESDPROC-113) for procedures for conducting these measurements.

If, after three well volumes have been removed, the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to five well volumes), should be removed. If the parameters have not stabilized within five volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible, with respect to turbidity. The conditions of sampling should be noted in the field log.

3.2.1.1.3 Purge Adequacy Considerations

In some situations, even with slow purge rates, a well may be pumped or bailed dry (evacuated). In these situations, this generally constitutes an adequate purge and the well can be sampled following sufficient recovery (enough volume to allow filling of all sample containers). ***It is not necessary that the well be evacuated three times before it is sampled***. The pH, specific conductance, temperature, and turbidity should be measured and recorded, during collection of the sample from the recovered volume, as the measurements of record for the sampling event.

For wells with slow recovery, attempts should be made to avoid purging them to dryness. This can be accomplished, for example, by slowing the purge rate. As water enters a well that has been purged to dryness, it may cascade down the sand pack and/or the well screen, stripping volatile organic constituents that may be present and/or introducing soil fines into the water column.

It is particularly important that wells be sampled as soon as possible after purging. If adequate volume is available immediately upon completion of purging, the well must be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells which have a slow recovery should be scheduled so that they can be purged and sampled in the same day, after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

3.2.2 “Tubing-in-Screened-Interval” Method

The “Tubing-in-Screen” method, sometimes referred to as the “Low Flow” method, is used primarily when calculated purge volumes for the traditional purging method are excessive and present issues related to timely completion of the project and/or management of investigation derived waste.

3.2.2.1 Purge Criteria

3.2.2.1.1 Placement of Pump Tubing or Intake

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. By definition, this method cannot be applied for purging with a bailer.

3.2.2.1.2 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well being sampled to monitor the static water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. If this condition cannot be met, then one of the other methods should be employed.

3.2.2.1.3 Stability of Chemical Parameters

As with the traditional purging method described in Section 3.2.1, it is important that all chemical parameters be stable as defined in Section 3.2.1.1 prior to sampling.

3.3 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The equipment utilized by Branch personnel will usually consist of peristaltic pumps and variable speed electric submersible pumps, but may also include bladder pumps or inertial pumps. The pump of choice is usually a function of the well diameter, the depth to water, the depth of the well and the amount of water that is to be removed during purging. Whenever the head difference between the sampling location and the water level is less than the limit of suction and the volume to be removed is reasonably small, a peristaltic pump should be used for purging. For wells where the water level is below the limit of suction (approximately 25’ to 30’, and/or where there is a large volume of water to be purged), the variable speed electric submersible pump would be the pump of choice. SESD Operating Procedure for Pump Operation (SESDPROC-203) contains the use and operating instructions for all pumps commonly used during SESD ground water investigations.

Bailers may also be used for purging in appropriate situations, however, their use is discouraged. Bailers tend to disturb any sediment that may be present in the well, creating or increasing sample turbidity. Bailers, if improperly used, may also strip volatile organic compounds from the water column being sampled. If a bailer is used, it should be a closed-top Teflon® bailer.

3.3.1 Wells Without Plumbing or In-Place Pumps

For permanent monitoring wells, the depth to water (water level) and depth of the well (total depth) should be determined before purging. Caution should be exercised during this procedure to prevent cross-contamination between wells. This is a critical concern when samples for trace organic compounds or metals analyses are collected. See SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205**)** for cleaning procedures for well sounders. After cleaning, the well sounding device should be protected to keep it clean until its next use.

3.3.1.1 Purging with Pumps

3.3.1.1.1 Peristaltic Pumps

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206)) Teflon® tubing, equal to the well depth plus an additional five to ten feet. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.

2. Place one end of the tubing into the vacuum side of the peristaltic pump head. Proper sizing of the Teflon® and Silastic® or Tygon® tubing should allow for a snug fit of the Teflon® tubing inside the flexible tubing mounted in the pump head.

3. Run a short section of tubing (does not have to be Teflon®) from the discharge side of the pump head to a graduated bucket.

4. Place the free end of the Teflon® tubing into the well until the end of the tubing is just below the surface of the water column.

5. Secure the Teflon® tubing to the well casing or other secure object using electrician's tape or other suitable means. This will prevent the tubing from being lost in the well should the tubing detach from the pump head.

6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.

7. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.

8. For wells which are not evacuated to dryness, particularly those with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging. Standard field measurements should frequently be taken during this process to verify adequacy of the purge and readiness for sampling, as described in Section 3.

3.3.1.1.2 Submersible Pumps

When a submersible pump is used for well purging, the pump itself is lowered into the water column. The pump must be cleaned as specified in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

The pump/hose assembly used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. It is recommended that the pump not be lowered more than three to five feet into the water column. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is within one foot of the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown. After the pump is removed from the well, the hose and the pump should be cleaned as outlined in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

3.3.1.2 Purging with Bailers

Standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206)), closed top Teflon® bailers with Teflon® coated stainless steel leaders and new nylon rope are lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

3.3.2 Wells With In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, etc. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps. The objective of purging wells with in-place pumps is the same as with monitoring wells without in-place pumps, i.e., to ultimately collect a ground water sample representative of aquifer conditions. Among the types of wells identified in this section, two different approaches are necessary.

A permanent monitoring well with an in-place pump should, in all respects, be treated like a monitoring well without a pump. One limitation is that in most cases the in-place pump is “hard” mounted, that is, the pump is suspended in the well at a pre-selected depth and cannot be moved up or down during purging and sampling. In these cases, well volumes are calculated, parameters are measured and the well is sampled from the pump discharge, after volume removal and parameter conditions have been met.

In the case of the other types of wells, i.e., municipal, industrial and residential supply wells, however, not enough is generally known about the construction aspects of the wells to apply the same criteria as used for monitoring wells, i.e., 3 to 5 well volumes. The volume to be purged in these situations, therefore, depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing under the conditions described.

3.3.2.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be located between the pump and the storage tank. If not, locate the valve closest to the tank. Measurements of pH, specific conductance, temperature, and turbidity are recorded at the time of sampling.

3.3.2.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Generally, under these conditions, 15 to 30 minutes will be adequate. Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purge and the final measurements made at the time of sampling should be considered the measurements of record for the event.

3.3.3 Temporary Monitoring Wells

3.3.3.1 General Considerations

Procedures used to purge temporary ground water monitoring wells differ from permanent wells because temporary wells are installed for immediate sample acquisition. Wells of this type may include standard well screen and riser placed in boreholes created by hand augering, power augering, or by drilling. They may also consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler or a Hydropunch® sampler. As such, the efforts to remove several volumes of water to replace stagnant water do not necessarily apply because stagnant water is not present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply, to the extent possible, standard permanent monitoring well purging criteria to it to re-achieve aquifer conditions.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, resulting primarily in increased turbidity. Therefore, the goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low stress purging techniques using variable speed peristaltic pumps.

3.3.3.2 Purging When Water Level Is Within Limit of Suction

In situations where the elevation of the top of the water column is within the limit of suction (no greater than about 25 feet head difference between the pump and the water level), a variable speed peristaltic pump may be used to purge temporary wells. Enough tubing is deployed to reach the bottom of the temporary well screen. At the onset of purging, the tubing is slowly lowered to the bottom of the screen and is used to remove any formation material which may have entered the well screen during installation. This is critical to ensuring rapid achievement of low turbidity conditions. After the formation material is removed from the bottom of the screen, the tubing is slowly raised through the water column to near the top of the column. The tubing can be held at this level to determine if the pump rate is drawing down the water level in the well. If the water level remains the same, secure the tubing at the surface to maintain this pumping level.

If drawdown is observed on initiation of pumping, reduce the pump speed and attempt to match the drawdown of the well. Sustained pumping at these slow rates will usually result in a relatively clear, low turbidity sample. If the drawdown stabilizes, maintain that level, however, if it continues to lower, "chase" the water column until the well is evacuated. In this case, the recovered water column may be relatively free of turbidity and can be sampled. It may take several episodes of recovery to provide enough volume for a complete sample.

3.3.3.3 Purging When Water Level Is Greater Than Limit of Suction

In situations where the elevation of the water table is greater than the limit of suction, peristaltic pumps cannot be used to purge temporary wells. If the temporary well is a ScreenPoint15® sampler with small diameter probe rod riser, the only practical choices for water removal are a small diameter bailer, a small diameter bladder pump or an inertial pump. If the well is to be used strictly for VOC screening, it may be acceptable to use the bailer to bail as much sediment from the well as possible prior to sampling. If metals are the analytes of concern, the bladder pump is the best choice for lowering the turbidity of the water column prior to sampling, followed next by the inertial pump. For larger diameter temporary wells, two-inch diameter or greater, bailers and the Grundfos® RediFlo2 may be used although excessive silt or other “fines” may present problems with the operation of the pump.

3.3.3.4 Considerations for Direct Push Groundwater Sampling

With many of the direct push sampling techniques, purging is either not practical or possible, therefore, no purging is conducted. The sampling device is simply pushed or driven to the desired depth and opened and the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the subject procedure may yield a turbid sample that is not appropriate for metals analyses.

3.4 Field Care of Purging Equipment

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible pumps to purge wells which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative purging methods, such as bailers, should be considered.

3.5 Investigation Derived Waste

Purging generates quantities of purge water or investigation derived waste (IDW), the disposition of which must be considered. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for guidance on management or disposal of this waste.

4 Groundwater Sampling Methods – Sampling

4.1 General

Sampling is the process of obtaining, containerizing, and preserving (if required) a ground water sample after the purging process is complete. Non-dedicated pumps for sample collection generally should not be used. Many pumps are made of materials such as brass, plastic, rubber, or other elastomeric products which may cause chemical interferences with the sample. Their principle of operation may also render them unacceptable as a sample collection device. It is recognized that there are situations, such as industrial or municipal supply wells or private residential wells, where a well may be equipped with a dedicated pump from which a sample would not normally be collected. Discretion should always be used in obtaining a sample.

4.2 Sampling Wells With In-Place Plumbing

Samples should be collected following purging from a valve or cold water tap as near to the well as possible, preferably prior to any storage/pressure tanks or physical/chemical treatment system that might be present. Remove any hose that may be present before sample collection and reduce the flow to a low level to minimize sample disturbance, particularly with respect to volatile organic constituents. Samples should be collected directly into the appropriate containers as specified in the ASBLOQAM. It may be necessary to use a secondary container, such as a clean 8 oz. or similar size sample jar or a stainless steel scoop, to obtain and transfer samples from spigots with low ground clearance. Also, refer to the discussion in the SESD Operating Procedure for Potable Water Supply Sampling (SESDPROC-305), Sec. 4.2, Potable Water Samples Collected from Wells with In-Place Plumbing**.** Potable well measurements for pH, specific conductance and turbidity and possibly temperature, if warranted, should be recorded at the time of sample collection.

4.3 Sampling Wells Without Plumbing, Within the Limit of Suction

4.3.1 Equipment Available

The pump of choice for sampling ground water within the limit of suction is the variable-speed peristaltic pump. Its use is described in the following sections. Other acceptable alternatives that may be used under these conditions are the RediFlo2® electric submersible pump (with Teflon® tubing) and a closed-top Teflon® bailer.

4.3.1.1 Peristaltic Pump, Direct from Pump Head Tubing

Samples for some constituents, primarily inorganic analytes such as metals and cyanide, may be collected directly from the pump head tubing. This method is acceptable under the following conditions:

- The pump head tubing must be changed between sampling locations;

- The pump head tubing must be either be certified clean according to SESD's internal quality control program described in Section 3.2 of the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) or
- An equipment rinsate blank is collected by pumping de-ionized water through a piece of the tubing.

4.3.1.2 Peristaltic Pump/Vacuum jug

It is not acceptable to collect samples for organic compound analyses through the flexible tubing used in the pump head. When collecting samples for organic compound analyses it is necessary to use a vacuum container, placed between the pump and the well for sample collection. The following step-by-step procedures describe the process of sampling with a peristaltic pump and vacuum jug (see note following these procedures for collection of VOC samples):

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.

2. Insert the tubing into one of the ferrule nut fittings of a Teflon® vacuum container transfer cap assembly.

3. Place a suitable length of Teflon® tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.

4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table (limit of suction).

5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers. Because the 1-liter containers used by the Branch are rinsed with nitric acid during cleaning, they cannot be used for collecting samples to be analyzed for nitrogen sensitive parameters.

6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume. The use of Teflon® valves or ball check devices to retain the water column in the sample delivery tubing during the transfer phase, when large volumes of sample are required, is acceptable. These devices, however, must be constructed so that they may be completely disassembled and cleaned according to the procedures in SESD

Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

7. When sampling is completed, all Teflon® tubing should be discarded.

   NOTE: Samples for volatile organic compound analyses cannot be collected using this method. If samples for VOC analyses are required, they must be collected with a Teflon® or stainless steel bailer or by other approved methods, such as the "soda straw" method. The "soda straw" method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing. Either method is repeated, as necessary, until all vials are filled.

4.3.1.3 RediFlo2® Electric Submersible Pump (with Teflon® Tubing)

After purging has been accomplished with RediFlo2® electric submersible pump, the sample may be obtained directly from the pump discharge, provided that Teflon® tubing was used for the sample delivery line. The discharge rate of the pump should be reduced during volatile organic compound sample collection to minimize sample disturbance. Note, if the RediFlo2® electric submersible pump is used for sampling, the pump must undergo a full external and internal cleaning. In addition, pump rinsate blanks must be collected, at the appropriate frequency, to demonstrate that the pump has been adequately cleaned between wells.

4.3.1.4 Bailers

New bailer rope should be attached to the bailer via a Teflon® coated stainless steel wire. (If a bailer was used to purge the well, it may also be used to sample the well and new bailer rope is not required between purging and sampling). The bailer should be gently immersed in the top of the water column until just filled. At this point, the bailer should be slowly removed and the contents emptied into the appropriate sample containers.

4.4 Sampling Wells without Plumbing, Exceeding the Limit of Suction

All methods described previously in Section 4.3.2.1.3, RediFlo2® Electric Submersible Pumps, and Section 4.3.2.1.4, Bailers, are suitable sample methods where the water table is too deep to consider the use of a peristaltic pump for sampling.

4.5 Micro-Purge or No Purge Sampling Procedures

The Micro-Purge or No Purge sampling procedures are usually employed when it necessary to keep purge volumes to an absolute minimum. Among the Micro-Purge or No Purge procedures that might be employed are:

- Low pump rate sampling with peristaltic or submersible pumps (typical Micro-Purge sampling),
- HydraSleeve^{TM} or
- Passive diffusion bag (PDB) sampling

The use of these procedures is acceptable only when the site hydrogeology is well understood, with respect to the hydraulic conductivity of geologic materials within the well screen interval. The underlying assumption, when employing these procedures, is that the formation in which the well is screened has a high hydraulic conductivity ($K>10^{-5}$ cm/sec, for example), resulting in a state of equilibrium existing between the water standing in the screened interval and the formation water in which the well is screened. In this situation, the well is considered to be in a perpetually "purged" state and purging is not required.

These procedures are generally impractical for SESD to implement because of the general lack of hydrogeologic information for the sampled wells and the real necessity, in some cases, that the pumps be pre-deployed to overcome issues related to turbidity resulting from pump placement prior to sampling.

4.5.1 Sampling with Pumps

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well or other interval selected by the field team leader. If turbidity and its impact on metals analyses are a concern, a period of time sufficient should be allowed to mitigate effects of pump or tubing placement. After it has been determined that sampling may proceed, the pump is turned on and operated at a rate that does not cause significant drawdown of the water column, as measured using a water level sounder. During sampling, sufficient water to supply enough volume for the analytes of concern and the purge parameters is pumped. Purging should continue until purge parameters stabilize, generally three consecutive stable sets of readings, before samples are collected.

4.5.2 HydraSleeves^{TM}

HydraSleeeves^{TM} are grab sampling devices that are deployed in a closed configuration then opened in the desired interval for sample collection. The following is a summary of its operation:

1. Sampler placement - Reusable weight is attached and the HydraSleeve^{TM} is lowered and placed at the desired position in the well screen. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. Well is allowed to return to equilibrium.

2. Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level, and only minimal agitation during collection.

3. Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field measurement.

4.5.3 Passive Diffusion Bags

Passive diffusion bag (PDB) samplers are bags comprised of low-density polyethylene (LDPE) plastic and containing analyte-free water, preferably with no headspace. The bags are deployed, with stainless steel weights, to the desired sample interval and are allowed to equilibrate with the water at the point of deployment in the well. A deployment period of a minimum of 14 days is recommended to ensure equilibration prior to removal.

After 14 days, the bags and opened with a puncture device or other cutting implement and the contents transferred to containers for sampling or field measurement.

4.5.4 General Considerations for Micro-Purge or No-Purge Sampling

When using the Micro-Purge method, it may be advisable to deploy the tubing or pump in advance of sample collection. Introducing the tubing or pump into the screened interval is likely to dislodge sediment and other fines that have settled or bridged on the well screen material and the gravel pack media behind the screen. If sampling is conducted immediately, turbidity issues may render this method impractical from a parameter stability standpoint.

HydraSleevesTM and PDBs must be evaluated for appropriateness for analytes of concern.

4.6 Sample Preservation

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult the ASBLOQAM for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

4.7 Special Sample Collection Procedures

4.7.1 Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which comes into contact with the water in the well must be cleaned in accordance with the cleaning procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206). Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Blank samples should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump other than a peristaltic pump.

4.7.2 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, an adequate purge, with respect to turbidity, is often difficult to achieve. Removal and insertion of equipment after the purge and prior to actual sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to collect the aliquot for metals first. Therefore, the preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds and volatile organic compounds.

4.7.3 Filtering

As a standard practice, ground water samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter and used for flow system analysis and for the purpose of geochemical speciation modeling. Filtration is not allowed to correct for improperly designed or constructed monitoring wells, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the ground water sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis:

1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the SESD Guidance Document, Design and Installation of Monitoring Wells (SESDGUID-001).

2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with USEPA approved methods.

3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the following:

   - Redevelopment or re-installation of permanent ground water monitoring wells.
   - Implementation of low flow/low stress purging and sampling techniques.

4. Turbidity measurements should be taken during purging and sampling to demonstrate stabilization or lack thereof. These measurements should be documented in the field notes. If the ground water sample appears to have either a chemically-induced elevated turbidity, such as would occur with precipitate formation, or a naturally elevated colloid or fine, particulate-related turbidity, filtration will not be allowed.

If filtration is necessary for purposes of geochemical modeling or other **pre-approved** cases, the following procedures are suggested:

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.

2. Use a 5 µm pore-size filter for the purpose of determining the colloidal constituent concentrations. A 0.1 µm pore-size filter should be used to remove most non-dissolved particles.

3. Rinse the cartridge or barrel-type filter with 500 milliliters of the solute (groundwater to be sampled) prior to collection of sample. If a membrane filter is used, rinse with 100 milliliters of solute prior to sample collection.

Potential differences could result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from the following: 1) Metals in Ground Water: Sampling Artifacts and Reproducibility; 2) Filtration of Ground Water Samples for Metals Analysis; and 3) Ground Water Sampling - A Workshop Summary. See Section 1.4, References, for complete citation for these documents.

Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in the following: 1) Sampling for Organic Chemicals and Microorganisms in the Subsurface; 2) Handbook for Evaluating Water Bacteriological Laboratories; and 3) Microbiological Methods for Monitoring the Environment, Water and Wastes. See Section 1.4, References, for complete citation for these documents.

4.8 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

4.9 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water levels measured according to the SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations (Section 3.1.1, Purging and Purge Adequacy), pumping rates during purging (see below), and occasionally, drillers or boring logs. This information should be documented in the field records.

4.9.1 Well Pumping Rate – Bucket/Stop Watch Method

The pumping rate for a pump can be determined by collecting the discharge from the pump in a bucket of known volume and timing how long it takes to fill the bucket. The pumping rate should be in gallons per minute. This method shall be used primarily with pumps with a constant pump rate, such as gasoline-powered or electric submersible pumps. Care should be taken when using this method with some battery-powered pumps. As the batteries' charge decreases, the pump rate also decreases so that pumping rate calculations using initial, high pump rates may be erroneously high. If this method is used with battery-powered pumps, the rate should be re-checked frequently to ensure accuracy of the pumping rate calculations.

Region 4 USEPA

Operating Procedure, Soil Sampling

December 2011

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Soil Sampling**

Effective Date: December 20, 2011 **Number:** SESDPROC-300-R2

Authors

Name: Fred Sloan
Title: Environmental Engineer, Regional Expert
Signature: Date: 12/19/2011

Approvals

Name: Archie Lee
Title: Chief, Enforcement and Investigations Branch
Signature: Date: 12/19/11

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 12/19/11

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-300-R2, *Soil Sampling*, replaces SESDPROC-300-R1. **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Updated the Enforcement and Investigations Branch Chief to Archie Lee, and the Field Quality Manager to Bobby Lewis. **Revision History:** On the third sentence, replaced Field Quality Manager with Document Control Coordinator. **Section 1.2:** Added the following statement: Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use. **Section 1.3:** Revised the last sentence to reflect that the official copy of this procedure resides on the SESD local area network (LAN), and that the Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN. **Section 1.4:** Unused references removed. Reference to Method 5035 added. Alphabetized. **Section 1.5.2:** Added bullets #8 and #9. (Bullet #8 – Discussion of sampling in landscaped areas. Bullet #9 – Discussion of sampling in non-landscaped areas.) **Section 2:** The discussion of Method 5035 has been moved to its own Section (Section 3) for clarity. Subsequent Sections were re-numbered. **Section 4.1:** Added paragraphs #2 and #3. (The information on these paragraphs originally appeared as bullets #2 and #3 in Section 4.2.1.) In addition, determining the initial sampling depth is now defined in paragraph #2. **Section 4.2.1:** As mentioned above, deleted bullets #2 and #3 from this Section and moved this information to paragraphs #2 and #3 in Section 4.1. **Section 5.1:** On paragraph #1, rewrote sentences #2 and #3 for clarity. Added the last sentence. Added paragraph #2.	December 20, 2011

Section 5.3: Rewrote the last sentence in the paragraph to clarify that, "although the Macro-Core® sampler can be used as an open-barrel sampler, in SESD usage, the piston point is always used to prevent the collection of slough from the borehole sides." **Section 5.5:** Rewrote bullet #1 to clarify acceptable materials for liners. Rewrote bullet #3 (Core Catchers) to clarify that, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable. Added bullets #4 (Decontamination) and #5 (Decommissioning). **Section 6.1:** Added paragraph #2 to this section. (Determining the initial sampling depth is now defined.) **Section 7.1:** Added paragraph #2 to this section. (Determining the initial sampling depth is now defined.) **Section 8.1:** Added paragraph #2 to this section. (Determining the initial sampling depth is now defined.)	
SESDPROC-300-R1, *Soil Sampling*, replaces SESDPROC-300-R0. **General** Corrected any typographical, grammatical and/or editorial errors. **Title Page** Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch. **Section 1.3** Updated information to reflect that the procedure is located on the H: drive of the LAN. Clarified Field Quality Manager (FQM) responsibilities. **Section 1.4** Updated referenced operating procedures due to changes in title names. Alphabetized and revised the referencing style for consistency. **Section 1.5.1** Corrected the title of the Safety, Health, and Environmental Management Program Procedures and Policy Manual. **Section 1.5.2, 4th bullet** Added references to the CFR and IATA's Dangerous Goods Regulations. **Section 2.7** Updated referenced operating procedures due to changes in title names.	November 1, 2007
SESDPROC-300-R0, Soil Sampling, Original Issue	February 05, 2007

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TABLES

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting soil samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling soil samples in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a soil sample, the variant procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN, and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field X-Ray Fluorescence (XRF) Measurement, SESDPROC-107, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

US EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Most Recent Version (Method 5035)

US EPA. Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting soil samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting soil samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.

- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader in the project files.
- Sampling in landscaped areas: When sampling in landscaped areas, cuttings should be placed on plastic sheeting and returned to the borehole upon completion of the sample collection. Any ‘turf plug’ generated during the sampling process should be returned to the borehole.
- Sampling in non-landscaped areas: Return any unused sample material back to the auger, drill or push hole from which the sample was collected.

2 Special Sampling Considerations

2.1 Special Precautions for Trace Contaminant Soil Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different sample is collected and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be collected, handled and stored separately.
- All background samples shall be segregated from obvious high-concentration or waste samples. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly-contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other member(s) collect the samples.
- Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned according to procedures contained in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205), for collection of samples for trace metals or organic compound analyses.

2.2 Sample Homogenization

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 4.

2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same approximate volume.

3. All soil samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. ***Samples for VOC analysis are not homogenized.*** The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
- Two quarters should then be mixed to form halves.
- The two halves should be mixed to form a homogenous matrix.

  This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

4. Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

2.3 Dressing Soil Surfaces

Any time a vertical or near vertical surface is sampled, such as achieved when shovels or similar devices are used for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels.

2.4 Quality Control

If possible, a control sample should be collected from an area not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same soil type. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by sampling tools. SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) contains other procedures that may be applicable to soil sampling investigations.

2.5 Records

Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation, as described in the SESD Operating Procedure for Logbooks (SESDPROC-010) and the SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005).

3 Method 5035

The procedures outlined here are summarized from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Method 5035.*

3.1 Soil Samples for Volatile Organic Compounds (VOC) Analysis

If samples are to be analyzed for volatile organic compounds, they should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with an auger bucket, the sample for VOC analysis should be collected directly from the auger bucket (preferred) or from minimally disturbed material immediately after an auger bucket is emptied into the pan. The sample shall be containerized by filling an En Core® Sampler or other Method 5035 compatible container. ***Samples for VOC analysis are not homogenized.*** Preservatives may be required for some samples with certain variations of Method 5035. Consult the method or the principal analytical chemist to determine if preservatives are necessary.

3.2 Soil Sampling (Method 5035)

The following sampling protocol is recommended for site investigators assessing the extent of volatile organic compounds (VOCs) in soils at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

3.2.1 Equipment

Soil for VOC analyses may be retrieved using any of the SESD soil sampling methods described in Sections 4 through 8 of this procedure. Once the soil has been obtained, the En Core® Sampler, syringes, stainless steel spatula, standard 2-oz. soil VOC container, or pre-prepared 40 mL vials may be used/required for sub-sampling. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

3.2.2 Sampling Methodology - Low Concentrations (<200 µg/kg)

When the total VOC concentration in the soil is expected to be less than 200 µg/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 mL pre-prepared vial) immediately to reduce volatilization losses. The 40 mL vials should contain 10 mL of organic-free water for an un-preserved sample or approximately 10 mL of organic-free water and a preservative. It is recommended that the 40 mL vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A soil sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 mL pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. soil jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 mL pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE: After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Soil samples may be prepared for shipping and analysis as follows:

En Core® Sampler - the sample shall be capped, locked, and secured in the original foil bag. All foil bags containing En Core® samplers are then placed in a plastic bag and sealed with custody tape, if required.

Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40-mL pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 mL containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

3.2.3 Sampling Methodology - High Concentrations (>200 µg/kg)

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Soils\sediments containing high total VOC concentrations may also be collected as described in Section 3.2.2, Sampling Methodology - Low Concentrations, and preserved using 10 mL methanol.

3.2.4 Special Techniques and Considerations for Method 5035

Effervescence

If low concentration samples effervesce from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved, as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence (rapid formation of bubbles) then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note that the amount of organic free water placed into the vials will have to be accurately measured.

Sample Size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size and the lack of sample mixing, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

Holding Times

Sample holding times are specified in the Analytical Support Branch *Laboratory Operations and Quality Assurance Manual* (ASBLOQAM), Most Recent Version. Field investigators should note that the holding time for an un-preserved VOC soil/sediment sample on ice is 48 hours. Arrangements should be made to ship the soil/sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

Percent Moisture and Preservative Compatibility (MOICA)

Samplers must ensure that the laboratory has sufficient material to determine percent moisture in the VOC soil/sediment sample to correct the analytical results to dry weight. If other analyses requiring percent moisture determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent moisture determination will be required. The sample collected for percent moisture may also be used by the laboratory to check for preservative compatibility.

Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities.

The summary table on the following page lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. SESD's goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

Table 1: Method 5035 Summary

OPTION	PROCEDURE	ADVANTAGES	DISADVANTAGES
1	Collect two 40 mL vials with ≈ 5 grams of sample, and one 2 oz. glass jar w/septum lid for screening, % moisture and preservative compatibility.	Screening conducted by lab.	Presently a 48-hour holding time for unpreserved samples. Sample containers must be tared.
2	Collect three En Core® samplers, and one 2 oz. glass jar w/septum lid for screening, % moisture and preservative compatibility.	Lab conducts all preservation/preparation procedures.	Presently a 48- hour holding time for preparation of samples.
3	Collect two 40 mL vials with 5 grams of sample and preserve w/methanol or sodium bisulfate, and one 2-oz. glass jar w/septum lid for screening, % moisture and preservative compatibility.	High level VOC samples may be composited. Longer holding time.	Hazardous materials used in the field. Sample containers must be tared.
4	Collect one 2-oz. glass jar w/septum lid for analysis, % moisture and preservative compatibility (high level VOC only).	Lab conducts all preservation/preparation procedures.	May have significant VOC loss.

4 Manual Soil Sampling Methods

4.1 General

These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 3 inches for risk assessment purposes. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual collection methods becomes impractical.

If a thick, matted root zone, gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials.

When compositing, make sure that each composite location (aliquot) consist of equal volumes, i.e., same number of equal spoonfuls.

4.2 Spoons

Stainless steel spoons may be used for surface soil sampling to depths of approximately 6 inches below ground surface where conditions are generally soft and non-indurated, and there is no problematic vegetative layer to penetrate.

4.2.1 Special Considerations When Using Spoons

- When using stainless steel spoons, consideration must be given to the procedure used to collect the volatile organic compound sample. If the soil being sampled is cohesive and holds its in situ texture in the spoon, the En Core® Sampler or syringe used to collect the sub-sample for Method 5035 should be plugged directly from the spoon. If, however, the soil is not cohesive and crumbles when removed from the ground surface for sampling, consideration should be given to plugging the sample for Method 5035 directly from the ground surface at a depth appropriate for the investigation Data Quality Objectives.

4.3 Hand Augers

Hand augers may be used to advance boreholes and collect soil samples in the surface and shallow subsurface intervals. Typically, 4-inch stainless steel auger buckets with cutting heads are used. The bucket is advanced by simultaneously pushing and turning using an attached handle with extensions (if needed).

4.3.1 Surface Soil Sampling

When conducting surface soil sampling with hand augers, the auger buckets may be used with a handle alone or with a handle and extensions. The bucket is advanced to the appropriate depth and the contents are transferred to the homogenization container for processing. Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

4.3.2 Subsurface Soil Sampling

Hand augers are the most common equipment used to collect shallow subsurface soil samples. Auger holes are advanced one bucket at a time until the sample depth is achieved. When the sample depth is reached, the bucket used to advance the hole is removed and a clean bucket is attached. The clean auger bucket is then placed in the hole and filled with soil to make up the sample and removed.

The practical depth of investigation using a hand auger depends upon the soil properties and depth of investigation. In sand, augering is usually easily performed, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. Hand augers may also be of limited use in tight clays or cemented sands. In these soil types, the greater the depth attempted, the more difficult it is to recover a sample due to increased friction and torqueing of the hand auger extensions. At some point these problems become so severe that power equipment must be used.

4.3.3 Special Considerations for Soil Sampling with the Hand Auger

- Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035. Collect the VOC sample directly from the auger bucket, if possible.
- Power augers, such as the Little Beaver® and drill rigs may be used to advance boreholes to depths for subsurface soil sampling with the hand auger. They may not be used for sample collection. When power augers are used to advance a borehole to depth for sampling, care must be taken that exhaust fumes, gasoline and/or oil do not contaminate the borehole or area in the immediate vicinity of sampling.
- When moving to a new sampling location, the entire hand auger assembly must be replaced with a properly decontaminated hand auger assembly.

5 Direct Push Soil Sampling Methods

5.1 General

These methods are used primarily to collect shallow and deep subsurface soil samples. Three samplers are available for use within the Division's direct push tooling inventory. All of the sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe each of the specific sampling methods that can be accomplished using direct push techniques, along with details specific to each method. While SESD currently uses the sample tooling described, tooling of similar design and materials is acceptable.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

5.2 Large Bore® Soil Sampler

The Large Bore® (LB) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of depth-discrete subsurface soil samples. The sample barrel is approximately 30-inches (762 mm) long and has a 1.5-inch (38 mm) outside diameter. The LB® sampler is capable of recovering a discrete sample core 22 inches x 1.0 inch (559 mm x 25 mm) contained inside a removable liner. The resultant sample volume is a maximum of 283 mL.

After the LB® sample barrel is equipped with the cutting shoe and liner, the piston-rod point assembly is inserted, along with the drive head and piston stop assembly. The assembled sampler is driven to the desired sampling depth, at which time the piston stop pin is removed, freeing the push point. The LB® sampler is then pushed into the soil a distance equal to the length of the LB® sample barrel. The probe rod string, with the LB® sampler attached, is then removed from the subsurface. After retrieval, the LB® sampler is then removed from the probe rod string. The drive head is then removed to allow removal of the liner and soil sample.

5.3 Macro-Core® Soil Sampler

The Macro-Core® (MC) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard MC® sampler has an assembled length of approximately 52 inches (1321 mm) with an outside diameter of 2.2 inches (56 mm). The MC® sampler is capable of recovering a discrete sample core 45 inches x 1.5 inches (1143 mm x 38 mm) contained inside a removable liner. The resultant sample volume is a maximum of 1300 mL. The MC® sampler may be used in either an open-tube or closed-point configuration. Although the

MC® sampler can be used as an open-barrel sampler, in SESD usage, the piston point is always used to prevent the collection of slough from the borehole sides.

5.4 Dual Tube Soil Sampling System

The Dual Tube 21 soil sampling system is a direct push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch (54 mm) OD probe rod. The samples are collected within a liner that is threaded onto the leading end of a string of 1.0-inch diameter probe rod. Collected samples have a volume of up to 800 mL in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core. Use of this method allows for collection of continuous core inside a cased hole, minimizing or preventing cross-contamination between different intervals during sample collection. The outer casing is advanced, one core length at a time, with only the inner probe rod and core being removed and replaced between samples. If the sampling zone of interest begins at some depth below ground surface, a solid drive tip must be used to drive the dual tube assembly and core to its initial sample depth.

5.5 Special Considerations When Using Direct Push Sampling Methods

- *Liner Use and Material Selection* – Direct Push Soil Samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terepthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most SESD investigations, the standard polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary.

- *Sample Orientation* – When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

- *Core Catchers* – Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In cases such as these, the use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability.

However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.

- *Decontamination* – The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified for the collection of trace organic and inorganic compounds found in Field Equipment and Decontamination – SESDPROC-205, most recent version. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes using the procedures specified for downhole drilling equipment in Field Equipment and Decontamination – SESDPROC-205, most recent version.

- *Decommissioning* – Boreholes must be decommissioned after the completion of sampling. Boreholes less than 10 feet depth that remain open and do not approach the water table may be decommissioned by pouring 30% solids bentonite grout from the surface, or pouring bentonite pellets from the surface, hydrating the pellets in lifts. Boreholes deeper than 10 feet, or any borehole that intercepts groundwater, must be decommissioned by pressure grouting with 30% solids bentonite grout, either through a re-entry tool string or through tremie pipe introduced to within several feet of the borehole bottom.

- *VOC Sample Collection* – Observe precautions for volatile organic compound sample collection found in Section 3 of this procedure.

6 Split Spoon/Drill Rig Methods

6.1 General

Split spoon sampling methods are used primarily to collect shallow and deep subsurface soil samples. All split spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the sub used to attach the spoon to the string of drill rod. Two basic methods are available for use, including the smaller diameter standard split spoon, driven with the drill rig safety hammer, and the larger diameter continuous split spoon, advanced inside and slightly ahead of the lead auger during hollow stem auger drilling. The following sections describe each of the specific sampling methods, along with details specific to each method.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

6.2 Standard Split Spoon

A drill rig is used to advance a borehole to the target depth. The drill string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0-inches OD (1.5-inches ID) and 18-inches to 24-inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition.

6.3 Continuous Split Spoon

The continuous split spoon is a large diameter split spoon that is advanced into the soil column inside a hollow stem auger. Continuous split spoons are typically 3 to 5 inches in diameter and either 5 feet or 10 feet in length, although the 5-foot long samplers are most common. After the auger string has been advanced into the soil column a distance equal to the length of the sampler being used it is returned to the surface. The sampler is removed from inside the hollow stem auger and the threaded collars are removed. The split spoon is then opened for sampling.

6.4 Special Considerations When Using Split Spoon Sampling Methods

- Always discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during inserting the split spoon.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

7 Shelby Tube/Thin-Walled Sampling Methods

7.1 General

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses, such as hydraulic conductivity and permeability, to support hydrogeologic characterizations at hazardous waste and other sites.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with this device.

7.2 Shelby Tube Sampling Method

A typical Shelby tube is 30 inches in length and has a 3.0-inch OD (2.875-inch ID) and may be constructed of steel, stainless steel, galvanized steel, or brass. They also typically are attached to push heads that are constructed with a ball-check to aid in holding the contained sample during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable.

To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force. After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition. If the sample is collected for geotechnical parameters, the tube is typically capped, maintaining the sample in its relatively undisturbed state, and shipped to the appropriate geotechnical laboratory.

7.3 Special Considerations When Using Split Spoon Sampling Methods

Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

8 Backhoe Sampling Method

8.1 General

Backhoes may be used in the collection of surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. If possible, the sample should be collected without entering the trench. Samples may be obtained from the trench wall or they may be obtained directly from the bucket at the surface. The following sections describe various techniques for safely collecting representative soil samples with the aid of a backhoe.

The depth measurement for the sample begins at the top of the soil horizon.

8.2 Scoop-and-Bracket Method

If a sample interval is targeted from the surface, it can be sampled using a stainless steel scoop and bracket. First a scoop and bracket are affixed to a length of conduit and is lowered into the backhoe pit. The first step is to take the scoop and scrape away the soil comprising the surface of the excavated wall. This material likely represents soil that has been smeared by the backhoe bucket from adjacent material. After the smeared material has been scraped off, the original stainless steel scoop is removed and a clean stainless steel scoop is placed on the bracket. The clean scoop can then be used to remove sufficient volume of soil from the excavation wall to make up the required sample volume.

8.3 Direct-from-Bucket Method

It is also possible to collect soil samples directly from the backhoe bucket at the surface. Some precision with respect to actual depth or location may be lost with this method but if the soil to be sampled is uniquely distinguishable from the adjacent or nearby soils, it may be possible to characterize the material as to location and depth. In order to ensure representativeness, it is also advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample.

8.4 Special Considerations When Sampling with a Backhoe

- Do not physically enter backhoe excavations to collect a sample. Use either procedure 8.2, Scoop-and-Bracket Method, or procedure 8.3, Direct-from-Bucket Method to obtain soil for sampling.
- Smearing is an important issue when sampling with a backhoe. Measures must be taken, such as dressing the surfaces to be sampled (see Section 2.3), to mitigate problems with smearing.

- Paint, grease and rust must be removed and the bucket decontaminated prior to sample collection.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

Region 4 USEPA

Operating Procedure, Field Equipment Cleaning and Decontamination

December 2011

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Equipment Cleaning and Decontamination**

Effective Date: December 20, 2011

Number: SESDPROC-205-R2

Authors

Name: Donald Hunter
Title: Environmental Scientist, Regional Expert
Signature: Donald Hunter Date: 12/16/11

Name: Doug Jager
Title: Environmental Scientist
Signature: Date: 12/16/11

Approvals

Name: Archie Lee
Title: Chief, Enforcement and Investigations Branch
Signature: Date: 12/19/11

Name: Bill Cosgrove
Title: Chief, Ecological Assessment Branch
Signature: Date: 12/19/11

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 12/19/11

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-205-R2, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R1. **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Changed the Enforcement and Investigations Branch Chief from Antonio Quinones to Archie Lee. Changed the Field Quality Manager form Laura Ackerman to Bobby Lewis. **Revision History:** Changed Field Quality Manager to Document Control Coordinator. **Section 1.2:** Added the following statement: Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use. **Section 1.3:** Omitted reference to the H: drive. Changed the Field Quality Manager to the Document Control Coordinator. **Section 1.4:** In definitions (third bullet), replaced “soap” with “detergent.” Changed all references in document from “soap” to “detergent.” **Section 1.5:** Updated references. **Section 2.1:** On the 2nd paragraph, removed the last two sentences and replaced with new language. The new language clarifies that any deviations from the standard decon procedures that need to be made during the course of the field investigation will be documented in the field logbook. **Section 3.5**: Revised to clarify that it is only necessary to decontaminate the wetted portion of the sounder or tape. **Section 3.6**: Rewritten to reflect updated RediFlo2® internal cleaning procedures. **Section 3.7:** Added Section 3.7.5, *Field Decontamination Procedure for Direct Push Technology (DPT) Equipment.*	December 20, 2011

SESDPROC-205-R1, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R0. **General** Corrected any typographical, grammatical and/or editorial errors. **Title Page** Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch. Changed Bill Cosgrove's title from Acting Chief to Chief. **Section 1.3** Updated information to reflect that the procedure is located on the H: drive of the LAN. Clarified Field Quality Manager (FQM) responsibilities. **Section 1.5** Alphabetized and revised the referencing style for consistency. **Section 1.6.1** Corrected the title of the Safety, Health, and Environmental Management Program Procedures and Policy Manual.	November 1, 2007
SESDPROC-205-R0, *Field Equipment Cleaning and Decontamination*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

1.2 Scope/Application

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the Field Equipment Center (FEC). On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on LAN and for maintaining records of review conducted prior to its issuance.

1.4 Definitions

- Decontamination: The process of cleaning dirty sampling equipment to the degree to which it can be re-used, with appropriate QA/QC, in the field.

- Deionized water: Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Deionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for deionized water.

- Detergent: A standard brand of phosphate-free laboratory detergent, such as Luminox®.

- Drilling Equipment: All power equipment used to collect surface and sub-surface soil samples or install wells. For purposes of this procedure, direct push is also included in this definition.

- Field Cleaning: The process of cleaning dirty sampling equipment such that it can be returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

- Organic-free water: Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

- Tap water: Water from any potable water supply. Deionized water or organic-free water may be substituted for tap water.

1.5 References

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.6 General Precautions

1.6.1 Safety

Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.

- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

1.6.2 Procedural Precaution

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

2 Introduction to Field Equipment Cleaning and Decontamination

2.1 General

The procedures outlined in this document are intended for use by field investigators for cleaning and decontaminating sampling and other equipment in the field. These procedures should be followed in order that equipment is returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for the Data Quality Objectives (DQOs) of the study or investigation. If deviations from these procedures need to be made during the course of the field investigation, they will be documented in the field logbook along with a description of the circumstances requiring the use of the variant procedure.

Cleaning procedures for use at the Field Equipment Center (FEC) are found in SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

2.2 Handling Practices and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- Detergent must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.

- Tap water may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

- Deionized water must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

- Organic-free water must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

2.3 Disposal of Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW); including used wash water and rinse water are in SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202).

2.4 Sample Collection Equipment Contaminated with Concentrated Materials

Equipment used to collect samples of concentrated materials from investigation sites must be field cleaned before returning from the study. At a minimum, this should consist of washing with detergent and rinsing with tap water. When the above procedure cannot be followed, the following options are acceptable:

1. Leave with facility for proper disposal;
2. If possible, containerize, seal and secure the equipment and leave on-site for later disposal;
3. Containerize, bag or seal the equipment so that no odor is detected and return to the SESD.

It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.5 Sample Collection Equipment Contaminated with Environmental Media

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

1. Wipe the equipment clean;
2. Water-rinse the equipment;
3. Wash the equipment in detergent and water followed by a tap water rinse.
4. For grossly contaminated equipment, the procedures set forth in Section 2.4 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the FEC without being field cleaned. If possible, FEC personnel should be notified that equipment will be returned without being field cleaned. It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.6 Handling of Decontaminated Equipment

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

3 Field Equipment Decontamination Procedures

3.1 General

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

3.2 Specifications for Decontamination Pads

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.

- The pad should not leak.

- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.

- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.

- Water should be removed from the decontamination pad frequently.

- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

3.3 "Classical Parameter" Sampling Equipment

"Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 3.3 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

3.4 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

1. Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Luminox® detergent and high pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

2. Rinse thoroughly with tap water.

3. Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to air-dry.

4. All equipment must be wrapped with foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

3.5 Well Sounders or Tapes

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

1. Wash with detergent and tap water.
2. Rinse with tap water.
3. Rinse with deionized water.

3.6 Redi-Flo2® Pump

CAUTION – Do not wet the controller. Always disconnect power from the pump when handling the pump body.

The Redi-Flo2® pump and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on whether the pump is used solely for purging or used for purging and sampling.

3.6.1 Purge Only (Pump and Wetted Portion of Tubing or Hose)

1. Disconnect power and wash exterior of pump and wetted portion of the power lead and tubing or hose with detergent and water solution.
2. Rinse with tap water.
3. Final rinse with deionized water.
4. Place pump and reel in a clean plastic bag and keep tubing or hose contained in clean plastic or galvanized tub between uses.

3.6.2 Purge And Sample

Grundfos Redi-Flo2® pumps are extensively decontaminated and tested at the FEC to prevent contamination from being transmitted between sites. The relevant sections of SESDPROC-206, *Field Equipment Cleaning and Decontamination at the FEC,* should be implemented in the field where a high risk of cross-contamination exists, such as where NAPL or high-concentration contaminants occur. In most cases, the abbreviated cleaning procedure described below will suffice.

1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately (See Section 3.6.3 for check valve). Wash the pump exterior with detergent and water.

2. Prepare and fill three containers with decontamination solutions, consisting of Container #1, a tap water/detergent washing solution; Container #2, a tap water rinsing solution; and Container #3, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution.

3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.

4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.

5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.

6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.

7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.

8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.

9. Place the pump and reel in a clean plastic bag.

3.6.3 Redi-Flo2® Ball Check Valve

1. Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.

2. Using a brush, scrub all components with detergent and tap water.
3. Rinse with deionized water.
4. Replace the ball check valve to the Redi-Flo2® pump head.

3.7 Downhole Drilling Equipment

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

3.7.1 Introduction

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 3.2 of this procedure.

Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam (200^{o} F plus), with a detergent compartment, should be obtained.

3.7.2 Preliminary Cleaning and Inspection

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (detergent and high pressure hot water), or wire brushing. Sandblasting should be performed <u>prior to arrival</u> on site, or well away from the decontamination pad and areas to be sampled.

- Any portion of the drilling equipment that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.

- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can provide materials without the printing and/or writing if specified when ordered. Items that cannot be cleaned are not acceptable and should be discarded.

- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

3.7.3 Drill Rig Field Cleaning Procedure

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) between boreholes.

3.7.4 Field Decontamination Procedure for Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does <u>not</u> apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 3.4 of this procedure.

1. Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

2. Rinse thoroughly with tap water.

3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

3.7.5 Field Decontamination Procedure for Direct Push Technology (DPT) Equipment

1. Certain specific procedures for the decontamination of DPT tools are described in the various sampling procedures, but the following general guidelines apply:

2. Prior to return to the Field Equipment Center, all threaded tool joints should be broken apart and the equipment cleaned per the provisions of *Section 2.5, Sample Collection Equipment Contaminated with Environmental Media* of this procedure.

3. Equipment that contacts the sample media and is cleaned in the field for reuse should be cleaned per the provisions of *Section 3.4, Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds* of this procedure. This would include piston sampler points and shoes, screen point sampler screens and sheaths, and the drive rods when used for groundwater sampling.

4. Equipment that does not directly contact the sample media and is cleaned in the field for reuse can generally be cleaned per the provisions of Section *3.7.4, Field Decontamination Procedure for Drilling Equipment* of this procedure.

Region 4 USEPA

Operating Procedure, Global Positioning System

April 2011

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Global Positioning System**

Effective Date: April 20, 2011

Number: SESDPROC-110-R3

Authors

Name: Jonathan Vail
Title: Environmental Scientist, Regional Expert
Signature: J Vail
Date: 4/14/2011

Name: Mel Parsons
Title: Life Scientist
Signature: Mel Parsons
Date: 4/14/11

Name: Brian Striggow
Title: Environmental Engineer
Signature:
Date: 4/18/11

Approvals

Name: Archie Lee
Title: Chief, Enforcement and Investigations Branch
Signature:
Date: 4/14/11

Name: Bill Cosgrove
Title: Chief, Ecological Assessment Branch
Signature:
Date: 4/14/11

Name: Liza Montalvo
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 4/14/11

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-110-R3, *Global Positioning System*, replaces SESDPROC-110-R2 **Cover Page:** The EIB Branch Chief was changed from Antonio Quinones to Archie Lee. The FQM was changed from Laura Ackerman to Liza Montalvo. **Revision History:** Changed Field Quality Manager to Document Control Coordinator. **Section 1.2:** Added the following statement: Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use. **Section 1.3:** Omitted the reference to the H: drive of the LAN. Changed Field Quality Manager to Document Control Coordinator.	April 20, 2011
SESDPROC-110-R2, *Global Positioning System*, replaces SESDPROC-110-R01 **Title Page** Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch. Changed Bill Cosgrove's title from Acting Chief to Chief. **Section 1.4** Alphabetized and added a reference.	November 1, 2007
SESDPROC-110-R1, *Global Positioning System*, replaces SESDPROC-110-R0 This revision reflects the following changes: **General** Extensive rewrite with additional information added to most sections. Brian Striggow added as coauthor. **Section 2.1** Rewritten description of GPS system. Descriptions of "GPS Accuracy Factors" and "Differential GPS" isolated as separate subsections.	October 1, 2007

Section 2.2 This Section, titled “Requirements for Locational Information” inserted. Supplies guidance on accuracy requirements for various study types and potential means used to obtain requisite accuracy. Subsection on datums and data formats included. **Section 2.3** “Quality Control Procedures”, previously numbered as Section 2.2. Most information in this section moved to Section 2.1 discussion of Accuracy Factors and Section 2.4 discussion of specific receivers. Explicit statement added that no specific GPS quality control procedures are required for most SESD studies. **Section 2.4** Information added to sections on Trimble and Garmin receivers. **Section 2.5** Issue of electronic data-logging addressed. Storage of electronic data records addressed.	
SESDPROC-110-R0, Global Positioning System, Original Issue	March 22, 2007

TABLE OF CONTENTS

Contents

1 General Information

1.1 Purpose

This document describes the Global Positioning System (GPS) and procedures, methods and considerations to be used and observed when using GPS to record location data in the field. Guidance is provided on accuracy requirements for various uses of location data and potential means to obtain the requisite accuracy. This document contains direction developed solely to provide internal guidance to SESD employees.

1.2 Scope/Application

The procedures contained in this document are to be used by SESD field investigators when using the Global Positioning System to obtain the geographical coordinates of sampling locations and/or measurements during field investigations. In SESD investigations, GPS is the preferred means of collecting horizontal location information. In most cases the accuracy of GPS is unsuitable for collection of elevation data.

On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain the required coordinate information and alternate procedures are employed, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. GPS users must be currently qualified as proficient in the operation of the specific GPS equipment to be used. The manufacturer's operation manuals should be used for detailed information on the use of specific GPS equipment. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Rand Corporation, The Global Positioning System, Assessing National Policies, Appendix B, GPS History, Chronology, and Budgets, 1995.

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version.

Trimble® Navigation Limited, Mapping Systems General Reference, Revision B, 1996.

USEPA, Global Position Systems – Technical Implementation Guidance, Office of Environmental Information (EPA/250/R-03/001), 2003.

USEPA, GIS Technical Memorandum 3. Global Positioning Systems – Technology and It's Application in Environmental Programs, Research and Development (PM-225). EPA/600/R-92/036, 1992.

USEPA, Locational Data Policy, Office of Information Resources Management, IRM Policy Manual 2100 Chapter 13, 1991.

2 Methodology

2.1 General

2.1.1 GPS Description

The Navigation Satellite Time and Ranging (NAVSTAR) Global Positioning System (GPS) is a worldwide radio-navigation system created by the U. S. Department of Defense (DOD) to provide navigation, location, and timing information for military operations. System testing using a limited number of satellites began in 1978 with the system being declared fully operational in 1995. The system was declared available for civilian uses in the 1980s and has seen burgeoning civilian application for navigation and mapping.

The GPS system consists of three basic elements: the space segment, control segment, and user segment. The space segment consists of the constellation of up to 24 active NAVSTAR satellites in six orbital tracks. The satellites are not in geo-synchronous orbit and are in constant motion relative to a ground user. The control segment consists of several ground stations that serve as uplinks to the satellites and that make adjustments to satellite orbits and clocks when necessary. The user segment consists of the GPS receiver which will typically consist of an antenna, multi-channel receiver, and processing unit.

For the purposes of this document, the user segment GPS receivers may be loosely grouped into Recreational and Navigational receivers (henceforth referred to as General Use receivers), Mapping Grade receivers, and Survey Grade receivers.

- Most General Use grade receivers are available on the retail market to consumers for a variety of applications including boating, hiking, and automotive navigation. They display an instantaneous reading of position and are generally not optimized for data collection. Waypoints containing instantaneous position fixes can often be stored and downloaded. The accuracy of these receivers is adequate for many environmental applications.

- Mapping Grade receivers are used for applications such as resource management and Geographical Information System (GIS) feature collection. The receivers are capable of averaging multiple position fixes for greater accuracy and then data-logging the results with sufficient information to post-correct the positions as described below. The potential accuracy that can be achieved may be better than one meter.

- Survey Grade receivers can provide accuracy at the centimeter level by using long occupation times and special techniques for receiver use and data processing. Survey Grade receivers are not used by SESD in field investigations.

GPS receivers derive positions by simultaneously measuring the distance (range) to several satellites in precisely known orbits, and using triangulation of the ranges to calculate a unique position for the receiver. The range to each satellite is determined by precisely measuring the transit time of radio signals broadcast from the satellites.

2.1.2 GPS Accuracy Factors

The accuracy of the basic GPS system is approximately 15m. GPS accuracy can be affected by a number of factors including the Selective Availability feature, atmospheric delays, satellite clock and orbit errors, multipath signals, signal strength, and satellite geometry relative to the user.

In the early GPS implementation, the DOD used a feature known as Selective Availability (SA) to degrade the quality and subsequent accuracy of the GPS signals to non-DOD users. With Selective Availability enabled, accuracy of position fixes could be as poor as 100m without the use of differential correction techniques described below. Currently there is no SA limitation in accuracy in place with a stated Executive Branch intention to not return to the use of the SA signal degradation.

As satellites move in their orbits and some signals are blocked by obstructions, the geometry of the available satellite signals relative to the user will constantly change. When the satellites with available signals are clustered closely together in the sky, small errors in range will result in large errors in reported position. Conversely, when the satellites are distributed more broadly across the sky, the resultant position errors will be at their minimum. The general measure of this phenomenon is Dilution of Precision (DOP), which may be represented as Position Dilution of Precision (PDOP), or more specifically for geographical coordinate collection, Horizontal Dilution of Precision (HDOP). Mapping and Survey Grade receivers generally can calculate and display DOP and allow the user to limit logging to times when the higher potential accuracy conditions of low DOP prevail. General Use receivers may display DOP and use DOP with other factors to estimate a general accuracy figure. DOP may range from approximately 2 to 50, with high quality work usually requiring a HDOP of less than 4-6.

Signal strength and multipath signals relate to the strength and quality of the signal reaching the receiver antenna. Signal attenuation by the atmosphere, buildings, and tree cover limit the accuracy of the ranges obtained. The measure of signal strength is Signal to Noise Ratio (SNR), generally measured in decibels(db). Most receivers of any grade will display the SNR of the satellite signals in a bar graph or table. Mapping Grade Receivers generally allow the user to specify a minimum signal strength for the use of a satellite signal (commonly 2-15db). Poor signal strength can be resolved by waiting for satellite locations to change or moving the receiver location. Multipath signals result from portions of the satellite signal bouncing off terrain, structures, or atmospheric disturbances, resulting in a degraded total signal. Higher quality Mapping Grade receivers may be capable of rejecting the stray multipath signals, such as Trimble® receivers using Everest™ technology.

2.1.3 Differential GPS

Selective Availability, clock errors, and orbital errors affect all GPS users and atmospheric delays affect all users over a relatively wide region. A second GPS receiver in the same general area as the user will experience the same errors from these sources as the user's receiver. Consequently, correction factors from a remote station at a known location can be applied to the user's receiver in a process known as Differential GPS (DGPS). DGPS can be applied in real-time using additional radio signals, or after the collection event by a method called post-correction.

Real-time DGPS uses established networks of base stations at precisely surveyed locations. The US Coast Guard operates a system of 80 base stations which became fully operational in 1999. The range corrections are broadcast on marine radiobeacon frequencies, with redundant coverage of most of the US coastline and the Mississippi River. There is near complete single beacon coverage of most of the internal US, but there are known gaps in coverage in both EPA Region 4 and the US as a whole. The system is sometimes referred to using the more general term DGPS or in nomenclature referring to the beacon-based nature of the system. Beacon-based DGPS is implemented primarily in Navigational and Mapping Grade receivers.

Real-time DGPS can also be implemented with a Space Based Augmentation System (SBAS). The most common SBAS currently used in the United States is the Wide Area Augmentation System (WAAS), developed by the Federal Aviation Administration to meet the additional demands on GPS for aircraft navigation. The WAAS network of base stations collects information on satellite clock errors, orbital errors, and atmospheric conditions. The error information is transferred to satellites in geo-synchronous orbits and subsequently broadcast to suitably equipped GPS receivers on frequencies compatible with the GPS range signals. While beacon-based DGPS passes range corrections to the receivers, WAAS communicates a model for the errors which is capable of providing more accurate corrections. Current Mapping Grade receivers will likely use WAAS with or without the option of beacon-based DGPS. All but the least expensive General Use receivers are generally equipped with WAAS differential correction capability.

Post-Corrected DGPS is generally accomplished by downloading the receiver survey files to a desktop or laptop computer and then retrieving correction files for the same time period (generally via the internet) from an established base station in the area of the survey. Post-processed accuracy improves with proximity of the base station to the surveyed locations and base station data should be used from a station within 300km of the site surveyed. The survey positions are processed by application software and a new set of positions is generated using the correction data. The capability for post-processed differential correction is generally limited to Mapping Grade and Survey Grade receivers.

Various factors limit GPS accuracy in the vertical plane to approximately half of that obtainable in the horizontal plane, i.e., if a location fix is accurate to 3 m in the horizontal plane, it may only be accurate to 6 m in the vertical plane. Since relatively high accuracy is usually required for the uses of elevation data, GPS is rarely used to obtain and report elevations.

2.2 Requirements for Locational Information

2.2.1 Data Uses

Locational information can serve many purposes in an environmental investigation, a few of which are listed below:

1. Providing an unambiguous means to identify facilities or sampling plats.
2. Providing locational information to key analytical data in a GIS based data archiving system to the original sampling locations.
3. Differentiating watersheds.
4. Providing information to calculate extents and volumes of contamination.
5. Providing a means to relocate the media represented by samples for removal or treatment.
6. Providing information to prepare presentation graphics of sampling locations.

Depending on the specific uses for the data and the type of work being performed, there will be different needs for the accuracy of the locational data. Studies where a sample represents a large area of relatively homogeneous material would not require the same accuracy as the location of a permanent monitoring well. Below are broad guidelines for the accuracy that might be required for different applications.

Desired Accuracy	**Application**
100 m	Open ocean work where sample is presumed to be representative of a large area
20 m	Open water work (lakes or estuaries) where sample is presumed to be representative of a large area
10 m	Stream and river work where samples are presumed to be broadly representative of a reach
5-3 m	Stream work where samples are representative of a specific narrowly defined section

10 m	Air Monitoring Stations
10 - 3 m	Microscale air monitoring
3 - 1 m	Permanent monitoring wells
1 m	Locations of 'Hot Spots' destined for removal of limited areal extent
3 - 1 m	Locations of Temporary groundwater wells in plumes requiring narrow delineation
3 m	Locations of Temporary groundwater wells in broad plumes
3 m	Locations of environmental samples with sample spacing >20 m
5 m	Locations of environmental samples with sample spacing >60 m
200 - 20 m	Coordinates describing a facility where mobile waste units are sampled
30 - 3 m	Locations of industrial process areas or NPDES permitted facilities where the sampling locations are described in field notes relative to the process or site features

Specific demands of a study may drive increased or decreased requirements for accuracy. The preferred means of locational data collection for most studies will be GPS, although alternate means are permissible if they meet accuracy requirements. The following table indicates the accuracy that may be expected from various means of establishing coordinates.

Accuracy	**Description**
200 - 50 m	Map Derived, coarse work
40 - 20 m	Map Derived, fine work or using GIS with digital imagery
15 m	General Use Grade GPS, w/o WAAS
5 m	General Use Grade GPS, w/ WAAS or beacon corrections
10 m	Mapping Grade GPS, no corrections, averaged readings,
3 m	Mapping Grade GPS w/ differential correction, averaged readings
1 m	Mapping Grade GPS w/ differential correction, controlled DOP and SNR, averaged readings
10 cm	Surveying Grade GPS or optical surveying (dependent on baseline length)

Accuracy is a term used to describe the degree of conformity of a measurement. In GPS, accuracy is usually specified as an estimate of the radius from the measured coordinates that is likely to include the actual coordinates. The estimate is based on several standard deviations probability of including the actual point in the measurement. As such, it is recognized that some measurements will fall outside of the specified accuracy. For the purposes of SESD GPS work, the nominal accuracy figures derived from manufacturer’s literature for specific operating conditions, displayed by the receiver at the time of feature collection, or output from processing software will be taken at face value.

2.2.2 Datums and Data formats

In general, a datum is a reference from which other measurements are taken. In the development of surveying systems by civil entities, different datums were used as base references that will result in differing coordinates for the same location. A GPS receiver will generally display coordinates in a number of different user-selected datums. **Unless there are specific requirements on a project, all SESD work should be conducted using the WGS84 datum. A**lternatively, the nearly equivalent NAD83 datum may be used if WGS84 is unavailable as a receiver option. If an alternate coordinate system is used where coordinates are obtained and recorded in field logbooks, the use of the alternate coordinate system should also be noted in the logbook.

The SESD Data Archival and Retrieval System (DART) requires that coordinates for sample locations be entered in the WGS84 datum and dd.dddddd format. Unless specific project requirements dictate otherwise, all coordinates explicitly stated in reports will be in WGS84 format and in all cases the datum used will be specified.

There is no SESD policy on significant digits for GPS information, and accuracy should not be implied from the presence of significant digits in reported coordinates. However, good scientific practice should be followed in the presentation of locational information in order that useful information not be truncated or a higher degree of accuracy implied. The following table shows the incremental distance in latitude represented by the least significant digit for various coordinate formats:

dd.dddddd°	Approximately 4" or 10 cm
dd.ddddd°	Approximately 44" or 1.1 m
dd.dddd°	Approximately 36' or 11 m
dd°mm'ss"	Approximately 100' or 30 m
dd°mm'ss.x"	Approximately 10' or 3 m
dd°mm'ss.xx"	Approximately 1' or 30 cm
dd°mm.xxxx'	Approximately 7" or 18 cm
dd°mm.xxx'	Approximately 6' or 1.8 m
dd°mm.xx'	Approximately 60' or 18 m

2.3 Quality Control Procedures

By nature of its origin in the DOD and recent application to aircraft navigation, the GPS is designed for high reliability. GPS failures resulting in an incorrect reading beyond the bounds of known errors are so rare that the possibility can be ignored for most SESD studies. If a study requires the verification of receiver function, this can be accomplished by verifying that a receiver displays the correct position while occupying a known benchmark.

2.4 Special Considerations

The application will dictate the type of receiver used. There are several specific considerations for the use of the various receiver types.

2.4.1 Special considerations for the use of Trimble® Mapping Grade Receivers

The suggested settings for Trimble® receivers are:

1. Position mode: Overdetermined 3D (or manual 3D if only 4 satellites are visible)
2. Elevation mask: 15 degrees
3. PDOP: 6
4. Signal to noise ratio (SNR) mask: 6
5. Dynamics code: Land
6. Logging interval: 1 second for points, 5 seconds for lines and areas
7. Audible click: Yes
8. Log DOP data: Yes
9. Coordinate System: Geographic Datum WGS84

When using Trimble® Geoexplorer receivers, the option of using the accuracy ‘slider bar’ display may be used to consolidate many of the above parameters. The slider bar position must be positioned at midscale or towards the ‘Precision’ end of the scale to achieve 1m accuracy work. When conducting work requiring less accuracy, the slider should be initially positioned midscale and may be adjusted toward the Production’ end of the scale if the higher level of accuracy can not be maintained.

The receivers may be configured to force real-time position correction. The use of real-time correction reduces the risk of being unable to obtain appropriate post-correction files, but may limit productivity when differential signals cannot be received or are intermittent. The use of forced real-time vs. post-correction is an operator decision. If the positions are not to be downloaded and the accuracy of differential correction is required, it will be necessary to force real-time correction.

Trimble® receivers at SESD contain a data dictionary that can facilitate the management of GIS data. If the COC_GIS dictionary is selected at the time of file creation, SESD standard media codes can be assigned to features at the time of logging that will accompany the data through the download process. The use of the COC_GIS data dictionary can simplify the management of the data when processed in a GIS system or when entered into the DART system.

The logging interval of most Trimble® GPS receivers defaults to a 5 second interval. This may be changed to a 1 second interval to expedite feature collection. A point feature should have a minimum of 36 positions logged to obtain the additional accuracy afforded by averaging positions. After a minimum of 36 positions are logged and the feature is closed, the averaged position can be obtained by selecting the feature on the 'Map' screen. The averaged position should always be the one entered into field notebooks.

Some Trimble® receivers may only display data in dd°mm'ss.sss" format. If the coordinates are downloaded and processed through Pathfinder Office software, they can be output in the dd.dddddd (or any other) format. If the coordinates were only recorded in field logbooks, they can be converted to decimal degrees as follows:

Converting to decimal degrees (dd.dddddd) from degrees°minutes'seconds" (dd°mm'ss.sss"):

dd.dddddd = dd + (mm/60) + (ss.sss/3600)

Example: Convert 33°28'45.241" to decimal degrees

33 + (28/60) + (45.241/3600) = 33.479236

The reverse conversion is accomplished as follows:

Converting to degrees°minutes'seconds" from decimal degrees

Starting with dd.dddddd

Multiply .dddddd by 60 to obtain mm.mmmm

Multiply .mmmm by 60 to obtain ss.sss

Then dd°mm'ss.sss" = dd & mm & ss.sss

Example: Convert 33.479236 to dd°mm’ss.sss” format

Multiply .479236 by 60 to obtain 28.7540 (mm.mmmm)

Multiply .7540 by 60 to obtain 45.241 (ss.sss)

Dd°mm’ss.sss” = 33° & 28’ & 45.241” = 33°28’45.241”

2.4.2 Special considerations for the use of Garmin® General Use Grade Receivers

The standard format for navigational purposes is decimal minutes (dd°mm.mmm’). This format is utilized due to the fact that nautical navigation charts are set up in this format. However, location information must be converted to a decimal degree (dd.ddddd°) format in order for GIS software to properly interpret the information. The conversion is accomplished by dividing the minutes portion of the coordinates by 60.

<u>Converting to decimal degrees from decimal minutes:</u>

dd.ddddd° = dd + (mm.mmm/60)

Example: Convert 81°49.386 degrees to decimal degrees

81 + (49.386/60) = 81.8231 degrees

<u>The reverse conversion is accomplished as follows:</u>

dd°mm.mmm’ = dd & (.ddddd*60)

Example: Convert 81.8231 degrees to decimal minutes (dd°mm.mmm’)

Multiply .8231 by 60 to obtain 49.386 (mm.mmm)

81° & 49.386’ = 81°49.386’

GPS users need to familiarize themselves with the differences between the two formats, as they appear similar. Spreadsheets can automate the conversion process.

2.5 Records

The GPS coordinates and the SESD equipment identification number of the GPS receiver should be recorded in field logbooks at the time of GPS coordinate collection. The data logging capability of receivers may be used in lieu of the requirement to record the coordinates in logbooks when the following conditions can be met:

1. The location can easily be found later if it needs to be resurveyed prior to demobilization. A permanent monitoring well can easily be resurveyed, while most open-water work would not afford this opportunity.

2. The data is downloaded and ascertained to meet the accuracy requirements for the project prior to demobilization from the site.

3. The data is stored in at least two separate locations for transport, such as a laptop hard drive and a flash drive or compact disc.

In all cases where positions are electronically recorded, the provisions of the Electronic Records section of the SESD Operating Procedure for Control of Records (SESDPROC-002) should be followed.

Where locational data is collected and processed electronically, but not reported explicitly in the final report, a copy of the coordinates in text format should be output and entered into the project file in paper or electronic form. The output should include:

1. Latitude, generally in dd.dddddd format.

2. Longitude, generally in dd.dddddd format.

3. Date of collection.

4. DOP information where it supports the accuracy requirements.

5. Correction status of each point where it supports the accuracy requirements.

6. The datum used for the export.

Trimble® Pathfinder Office will create files with this information by exporting to a text file. The information will be contained in the .pos and .inf files.

Region 4 USEPA

Design and Installation of Monitoring Wells

January 2013

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

GUIDANCE

Title: **Design and Installation of Monitoring Wells**

Effective Date: January 29, 2013

Number: SESDGUID-101-R1

Authors

Name: Brian Striggow
Title: Environmental Engineer

Signature:
Date: 1-22-13

Approvals

Name: Danny France
Title: Chief, Enforcement and Investigations Branch

Signature:
Date: 1-22-13

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division

Signature:
Date: 1/22/13

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDGUID-101-R1, *Design and Installation of Monitoring Wells*, replaces SESDPROC-101-R0. **General:** Corrected any typographical, grammatical and/or editorial errors. **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Antonio Quinones to Danny France. The FQM was changed from Laura Ackerman to Bobby Lewis. **Section 1.2:** Added the following statement: Mention of trade names or commercial products does not constitute endorsement or recommendation for use. **Section 1.3:** Omitted the reference to the H: drive of the LAN. **Section 1.4:** Replaced the "SESD Operating Procedure for Field Records and Documentation, SESDPROC-204-Most Recent Version" with its updated version, the "SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version. **Section 1.5.1:** Updated the SHEMP Manual reference to reflect that the most recent version of the Manual will be used. **Section 1.5.2:** On the second bullet, replaced the reference with the "SESD Operating Procedure for Logbooks (SESDPROC-010)."	January 29, 2013
SESDGUID-101-R0, *Design and Installation of Monitoring Wells*, Original Issue	February 18, 2008

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when designing and installing permanent and temporary groundwater monitoring wells to be used for collection of groundwater samples.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when designing, constructing and installing groundwater monitoring wells. On the occasion that SESD field personnel determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for any aspect of the design, construction and/or installation of a groundwater monitoring well, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

USEPA Region 4 Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM), November 2001

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Science and Ecosystem Support Division, Region 4, Athens, GA, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Groundwater Sampling, SESDPROC-301, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

EPA/540/S-95/503, *Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation*

ASTM standard D5092, *Design and Installation of Ground Water Monitoring Wells in Aquifers*

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when constructing and installing groundwater monitoring wells. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy (SHEMP) Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. Section 2.6, Safety Procedures for Drilling Activities, contains detailed and specific safety guidelines that must be followed by Branch personnel when conducting activities related to monitoring well construction and installation.

1.5.2 Procedural Precautions

The following precautions should be considered when constructing and installing groundwater monitoring wells.

- Special care must be taken to minimize or prevent inadvertent cross-contamination between borehole locations. Equipment, tools and well materials must be cleaned and/or decontaminated according to procedures found in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).
- All field activities are documented in a bound logbook according to the procedures found in SESD Operating Procedure for Logbooks (SESDPROC-010).

2 Permanent Monitoring Well Design Considerations

2.1 General

The design and installation of permanent monitoring wells involves drilling into various types of geologic formations that exhibit varying subsurface conditions. Designing and installing permanent monitoring wells in these geologic environments may require several different drilling methods and installation procedures. The selection of drilling methods and installation procedures should be based on field data collected during a hydrogeologic site investigation and/or a search of existing data. Each permanent monitoring well should be designed and installed to function properly throughout the duration of the monitoring program. When designing monitoring wells, the following should be considered:

- Short-and long-term objectives;
- Purpose of the well(s);
- Probable duration of the monitoring program;
- Contaminants likely to be monitored;
- Surface and subsurface geologic conditions;
- Properties of the aquifer(s) to be monitored;
- Well screen placement;
- General site conditions; and
- Potential site health and safety hazards.

In designing permanent monitoring wells, the most reliable, obtainable data should be utilized. Once the data have been assembled and the well design(s) completed, a drilling method(s) must be selected. The preferred drilling methods for installing monitoring wells are those that temporarily case the borehole during drilling and the construction of the well, e.g. hollow-stem augers and sonic methods. However, site conditions or project criteria may not allow using these methods. When this occurs, alternate methods should be selected that will achieve the project objectives. The following discussion of methods and procedures for designing and installing monitoring wells will cover the different aspects of selecting materials and methods, drilling boreholes, and installing monitoring devices.

2.2 Drilling Methods

The following drilling methods may be used to install environmental monitoring wells or collect samples under various subsurface conditions. In all cases the preferred methods are those that case the hole during drilling, i.e. Hollow Stem Augers (HSA) and sonic methods using an override system. Other methods may be used where specific subsurface or project criteria dictate.

2.2.1 Hollow Stem Auger (HSA)

This type of auger consists of a hollow, steel stem or shaft with a continuous, spiraled steel flight, welded onto the exterior. A hollow auger bit, generally with carbide teeth, disturbs soil material when rotated, whereupon the spiral flights transport the cuttings to the surface. This method is best suited in soils that have a tendency to collapse when disturbed. A monitoring well can be installed inside of hollow-stem augers with little or no concern for the caving potential of the soils. If caving sands exist during monitoring well installations, a drilling rig must be used that has enough power to extract the augers from the borehole without having to rotate them. A bottom plug, trap door, or pilot bit assembly can be used at the bottom of the augers to keep out most of the soils and/or water that have a tendency to enter the bottom of the augers during drilling. Potable water (analyzed for contaminants of concern) may be poured into the augers during drilling to equalize pressure so that the inflow of formation materials will be held to a minimum. Water-tight center bits are not acceptable because they create suction when extracted from the augers. This suction forces or pulls cuttings and formation materials into the augers, defeating the purpose of the center plug. Augering without a center plug or pilot bit assembly is permitted, provided that the soil plug, formed in the bottom of the augers, is removed before sampling or installing well casings. Removing the soil plug from the augers can be accomplished by drilling and washing out the plug using a rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. Bottom plugs can be used where no soil sampling is conducted during the drilling process. The bottom plug is wedged into the bottom of the auger bit and is knocked out at depth with drill pipe or the weight of the casing and screen assembly. The plug material should be compatible with the screen and casing materials. The use of wood bottom plugs is not acceptable. The type of bottom plug, trap door, or pilot bit assembly proposed for the drilling activity should be approved by a senior field geologist prior to drilling operations. Boreholes can be augered to depths of 150 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

2.2.2 Solid Stem Auger

This type of auger consists of a sealed hollow or solid stem or shaft with a continuous spiraled steel flight welded on the outside of the stem. An auger bit connected to the bottom disturbs soil material when rotated and the helical flights transport cuttings to the surface. At the desired depth the entire auger string is removed to gain access to the bottom of the borehole. This auger method is used in cohesive and semi-cohesive soils that do not have a tendency to collapse when disturbed. Boreholes can be augered to depths of 200 feet or more (depending on the auger size), but generally boreholes are augered to depths less than 100 feet.

Both of the previously discussed auger methods can be used in unconsolidated soils and semi-consolidated (weathered rock) soils, but not in competent rock.

Each method can be employed without introducing foreign materials into the borehole such as water and drilling fluids, minimizing the potential for cross contamination. Minimizing the risk of cross contamination is one of the most important factors to consider when selecting the appropriate drilling method(s) for a project.

2.2.3 Sonic Methods

These methods generally alternately advance concentric hollow drill stems using rotation in conjunction with axial vibration of the drill stem. After each stage of drill stem advancement, the inner string is removed with a core of drill cuttings while the outer 'override' string remains to hold the borehole open. The cuttings can be removed nearly intact from the inner casing for examination of the stratigraphy prior to sampling or disposal. Because there are no auger flights to increase the borehole diameter, the quantity of cuttings removed from the hole is minimized as compared to hollow stem augering. With moderate rotation, smearing of the formation materials on the borehole walls is reduced as well. This drilling method is useful in a variety of materials, from flowing sands to heavily consolidated or indurated formations.

In flowing sands, the drill casings can be filled and/or pressurized with potable water to prevent excess entry of formation materials into the drill string. The same QA/QC requirements for sampling of material introduced to the borehole apply as in other drilling methods. Because the amount of water introduced into the borehole can be significant, an approximation of the water used in the drilling process should be logged for use in estimating appropriate well development withdrawal.

Sonic drilling allows a larger diameter temporary casing to be set into a confining layer while drilling proceeds into deeper aquifers. This temporary casing is then removed during the grouting operation. In many cases this will be acceptable technique. However, the level of contamination in the upper aquifer, the importance of the lower aquifers for drinking water uses, the permeability and continuity of the confining layer, and state regulations should be taken into account when specifying this practice as opposed to permanent outer casing placed into the confining unit. Note that when using the temporary casing practice, it is critical that grout be mixed and placed properly as specified elsewhere in this section.

Because the total borehole diameter in sonic drilling is only incrementally larger than the inner casing diameter, particular care should be taken that the well casing is placed in the center of the drill stem while placing the filter pack. Centralizers should be used in most cases to facilitate centering, particularly in the case of deep wells with PVC casing.

2.2.4 Rotary Methods

These methods consist of a drill pipe or drill stem coupled to a drilling bit that rotates and cuts through the soils. The cuttings produced from the rotation of the drilling bit are transported to the surface by drilling fluids which generally consist of water, drilling mud, or air. The water, drilling mud, or air are forced down through the drill pipe, and out through the bottom of the drilling bit. The cuttings are then lifted to the surface between the borehole wall and the drill pipe, (or within a concentric drill stem in reverse rotary). Except in the case of air rotary, the drilling fluid provides a hydrostatic pressure that reduces or prevents borehole collapse. When considering this method, it is important to evaluate the potential for contamination when fluids and/or air are introduced into the borehole.

Due to the introduction of the various circulating fluids, the use of rotary methods requires that the potential for contamination by these fluids be evaluated. Water and mud rotary methods present the possibility of trace contamination of halogenated compounds when municipal water supplies are used as a potable water source. Air rotary drilling can introduce contamination through the use of lubricants or entrained material in the air stream. Unless contaminated formations are cased off, the circulation of drilling fluids presents a danger of cross contamination between formations. In any of the rotary (or sonic) methods, care must be exercised in the selection and use of compounds to prevent galling of drill stem threads.

2.2.4.1 Water Rotary

When using water rotary, potable water (that has been analyzed for contaminants of concern) should be used. If potable water (or a higher-quality water) is not available on-site, then potable water will have to be transported to the site or an alternative drilling method will have to be selected. Water does not clog the formation materials, but the suspended drilling fines can be carried into the formation, resulting in a very difficult to develop well. This method is most appropriate for setting isolation casing.

2.2.4.2 Air Rotary

Air rotary drilling uses air as a drilling fluid to entrain cuttings and carry them to the surface. High air velocities, and consequently large air volumes and compressor horsepower are required. “Down-the-hole” (DTH) percussion hammers driven by the air stream can be used with this method to rapidly penetrate bedrock materials. Where a casing through unconsolidated material is required to prevent borehole collapse, it can be driven in conjunction with advancement of the drill stem.

When using air rotary drilling in any zone of potential contamination, the cuttings exiting the borehole must be controlled. This can be done using the dual-tube reverse circulation method where cuttings are carried to the surface inside dual-wall drill pipe and separated with a cyclone separator. An air diverter with hose or pipe carrying cuttings to a waste container is also an acceptable alternative. Allowing cuttings to blow uncontrolled from the borehole is not acceptable.

When using air rotary, the issue of contaminants being introduced into the borehole by the air stream must be addressed. Screw compressor systems should have a coalescing filter system in good working order to capture excess entrained compressor oils. The lubricant to be used with DTH hammers as well as thread lubricants to be used on drill stem should be evaluated for their potential impact on analytical samples.

2.2.4.3 Mud Rotary

Mud rotary is an undesirable drilling method because contamination can be introduced into the borehole from the constituents in the drilling mud, cross contamination can occur along the borehole column, and it is difficult to remove the drilling mud from the borehole after drilling and during well development. The drilling mud can also carry contaminates from a contaminated zone to an uncontaminated zone thereby cross-contaminating the borehole. If mud rotary is selected, only potable water and pure (no additives) bentonite drilling muds should be used. All materials used should have adequate documentation as to manufacturer's recommendations and product constituents. QA/QC samples of drilling muds and potable water should be sampled at a point of discharge from the circulation system to assure that pumps and piping systems are not contributing cross-contamination from previous use.

2.2.5 Other Methods

Other methods such as the cable-tool method, jetting method, and boring (bucket auger) method are available. If these and/or other methods are selected for monitoring well installations, they should be approved by a senior field geologist before field work is initiated.

2.3 Borehole Construction

2.3.1 Annular Space

The borehole or hollow stem auger should be of sufficient diameter so that well construction can proceed without major difficulties. For open boreholes, the annular space should be approximately 2" to allow the uniform deposition of well materials around the screen and riser, and to allow the passage of tremie pipes and well materials without unduly disturbing the borehole wall. For example, a 2" nominal diameter (nom.) casing would require a 6" inside diameter (ID) borehole.

In hollow stem augers and sonic method drill casing, the ID should be of sufficient size to allow the passage of the tremie pipe to be used for well grout placement, as well as free passage of filter sands or bentonite pellets dropped through the auger or casing. In general, 4-1/4" ID should be the minimum size used for placement of 2" nom. casing and 8-1/4" ID for 4" nom. casing. Larger augers should be used where installation difficulties due to geologic conditions or greater depths are anticipated, e.g. larger augers might be required to place a bentonite pellet seal through a long water column.

2.3.2 Over-drilling the Borehole

Sometimes it is necessary to over-drill the borehole in anticipation of material entering the augers during center bit removal or knocking out of the bottom plug. Normally, 3 to 5 feet is sufficient for over-drilling. The borehole can also be over-drilled to allow for an extra space or a "sump" area below the well screen. This "sump" area provides a space to attach a 5 or 10 foot section of well casing to the bottom of the well screen. The extra space or "sump" below the well screen serves as a catch basin or storage area for sediment that flows into the well and drops out of suspension. These "sumps" are added to the well screens when the wells are screened in aquifers that are naturally turbid and will not yield clear formation water (free of visible sediment) even after extensive development. The sediment can then be periodically pumped out of the "sump" preventing the well screen from clogging or "silting up". If the borehole is inadvertently drilled deeper than desired, it can be backfilled to the design depth with bentonite pellets, chips, or the filter sand that is to be used for the filter pack.

2.3.3 Filter Pack Placement

When placing the filter pack into the borehole, a minimum of 6-inches of the filter pack material should be placed under the bottom of the well screen to provide a firm base. Also, the filter pack should extend a minimum of 2-feet above the top of the well screen to allow for settling and to isolate the screened interval from the grouting material. In open boreholes, the filter pack should be placed by the tremie or positive displacement method. Placing the filter pack by pouring the sand into an open drill stem is acceptable with the use hollow stem augers, and other methods where the borehole is temporarily cased down to the filter pack.

2.3.4 Filter Pack Seal – Bentonite Pellet Seal (Plug)

Bentonite pellets consist of ground, dried bentonite compacted into pellets available in several sizes. Bentonite pellets are compressed to a bulk density of 70-80 lbs/ft^3 and hydrate to a 30% min. solids material. Where neat cement grouts are to be used, the placement of a bentonite pellet seal above the filter pack is mandatory to prevent the possibility of grout infiltration into the screened interval prior to setting. Bentonite chips or other sealing products should not be substituted in this application. Where bentonite grouts are to be used, the placement of a bentonite pellet seal is optional, but desirable.

Since bentonite pellets begin hydrating rapidly, they can be very difficult to place properly. They are generally placed by pouring slowly into open boreholes, hollow stem augers or sonic drill pipe. In some cases, pellets are placed by tremie pipe and flushed into place with potable water. A tamper can be used to ensure that the material is being placed properly and to rapidly break up any pellet bridging that occurs.

Pellet seals should be designed for a two-foot thickness of dry pellets above the filter pack. Hydration may extend the height of the seal. Where neat cement grouts are to be used, the pellets should be hydrated for eight hours, or the manufacturer’s recommended hydration time, whichever is greater. Where the water table is temporarily below the pellet seal, potable (or higher quality) water should be added repeatedly to hydrate the pellets prior to grouting.

2.3.5 Grouting the Annular Space

The annular space between the casing and the borehole wall should be filled with either a 30% solids bentonite grout, a neat cement grout, or a cement/bentonite grout. Each type of grout selected should be evaluated as to its intended use and integrity. Bentonite grouts are preferred unless the application dictates the use of another material.

Bentonite grout shall be a 30% solids pure bentonite grout. Drilling muds are not acceptable for grouting. The grout should be placed into the borehole, by the tremie method, from the top of the bentonite seal to within 2-feet of the ground surface or below the frost line, whichever is the greater depth. The bentonite pellet seal or filter pack should not be disturbed during grout placement, either by the use of a side discharge port on the tremie tube, or by maintaining clearance between the bottom of the tremie tube and the bentonite seal or filter pack. The grout should be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. The preferred method of achieving proper solids content is by measurement of ingredients per the manufacturer’s specifications during mixing with a final check by grout balance after mixing. Bentonite grouts should have a minimum density of 10 lbs/gal to ensure proper gelling and low permeability. The density of the first batch of grout should be measured while mixing to verify proper measurement of ingredients. In addition, the grouting operation should not cease until the bentonite grout flowing out of the borehole has a minimum density of 10 lbs/gal. Estimating the grout density is not acceptable.

Cement grouts are generally dictated where a high level of dissolved solids or a particular dissolved constituent would prevent proper gelling of a bentonite grout. Neat cement grouts (cement without additives) should be mixed using 6 gallons of water per 94-lb bag of Type 1 Portland cement to a density of 15lbs/gal. The addition of bentonite (5 to 10 percent) to the cement grout can be used to delay the "setting" time and may not be needed in all applications. The specific mixtures and other types of cement and/or grout proposed should be evaluated on a case by case basis by a senior field geologist.

2.3.6 Above Ground Riser Pipe and Outer Casing

The well casing, when installed and grouted, should extend above the ground surface a minimum of 2.5 feet. A vent hole should be drilled into the top of the well casing cap to permit pressure equalization, if applicable. An outer protective casing should be installed into the borehole after the annular grout has cured for at least 24 hours. The outer protective casing should be of steel construction with a hinged, locking cap. Generally, outer protective casings used over 2-inch well casings are 4 inches square by 5 feet long. Similarly, protective casings used over 4-inch well casings are 6 inches square and 5 feet long. Other types of protective casing including those constructed of pipe are also acceptable. All protective casings should have sufficient clearance around the inner well casings, so that the outer protective casings will not come into contact with the inner well casings after installation. The protective casings should have a weep hole to allow drainage of accumulated rain or spilled purge water. The weep hole should be approximately 1/4-inch in diameter and drilled into the protective casings just above the top of the concrete surface pad to prevent water from standing inside of the protective casings. Protective casings made of aluminum or other soft metals are normally not acceptable because they are not strong enough to resist tampering. Aluminum protective casing may be used in very corrosive environments such as coastal areas.

Prior to installing the protective casing, the bentonite grout in the borehole annulus is excavated to a depth of approximately two feet. The protective casing is installed by pouring concrete into the borehole on top of the grout. The protective casing is then pushed into the wet concrete and borehole a minimum of 2 feet. Extra concrete may be needed to fill the inside of the protective casing so that the level of the concrete inside of the protective casing is at or above the level of the surface pad. In areas where frost heave of the surface pad is possible, the protective casing should first be pressed into the top surface of the bentonite grout seal and concrete poured around the protective casing. A granular material such as sand or gravel can then be used to fill the space between the riser and protective casing. The use of granular material instead of concrete between the protective casing and riser will also facilitate the future conversion of the well to a flush-mount finish, if required. The protective casing should extend above the ground surface to a height so that the top of the inner well casing is exposed when the protective casing is opened. At each site, all locks on the outer protective casings should be keyed alike.

2.3.7 Concrete Surface Pad

A concrete surface pad should be installed around each well at the same time as the outer protective casing is being installed. The surface pad should be formed around the well casing. Concrete should be placed into the pad forms and into the borehole (on top of the grout) in one operation making a contiguous unit. The size of the concrete surface pad is dependent on the well casing size. If the well casing is 2 inches in diameter, the pad should be 3 feet x 3 feet x 4 inches. If the well casing is 4 inches in diameter, the pad should be 4 feet x 4 feet x 6 inches. Round concrete surface pads are also acceptable. The finished pad should be slightly sloped so that drainage will flow away from the protective casing and off of the pad. A minimum of one inch of the finished pad should be below grade to prevent washing and undermining by soil erosion.

2.3.8 Surface Protection – Bumper Guards

If the monitoring wells are located in a high traffic area, a minimum of three bumper guards consisting of steel pipes 3 to 4 inches in diameter and a minimum 5-foot length should be installed. These bumper guards should be installed to a minimum depth of 2 feet below the ground surface in a concrete footing and extend a minimum of 3 feet above ground surface. Concrete should also be placed into the steel pipe to provide additional strength. Substantial steel rails and/or other steel materials can be used in place of steel pipe. Welding bars between the bumper posts can provide additional strength and protection in high traffic areas, but the protective bumpers should not be connected to the protective casing.

2.4 Construction Techniques

2.4.1 Well Installation

The borehole should be bored, drilled, or augered as close to vertical as possible, and checked with a plumb bob or level. Deviation from plumb should be within 1° per 50ft of depth. Slanted boreholes are undesirable and should be noted in the boring logs and final construction logs. The depth and volume of the borehole, including the over-drilling if applicable, should have been calculated and the appropriate materials procured prior to drilling activities.

The well casings should be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed by the use of centralizers and/or a plumb bob and level. Another method of placing the well screen and casings into the borehole and plumbing them at the same time is to suspend the string of well screen and casings in the borehole by means of a hoist on the drill rig. This wireline method is especially useful if the borehole is deep and a long string of well screen and casings have to be set and plumbed.

No lubricating oils or grease should be used on casing threads. No glue of any type should be used to secure casing joints. Teflon "O" rings can also be used to insure a tight fit and minimize leakage; however, "O" rings made of other materials are not acceptable if the well is going to be sampled for organic compound analyses.

Before the well screen and casings are placed on the bottom of the borehole, at least 6 inches of filter material should be placed at the bottom of the borehole to serve as a firm footing. The string of well screen and casings should then be placed into the borehole and plumbed. Centralizers can be used to plumb a well, but centralizers should be placed so that the placement of the filter pack, bentonite pellet seal, and annular grout will not be hindered. Centralizers placed in the wrong locations can cause bridging during material placement. Monitoring wells less than 50 feet deep generally do not need centralizers. If centralizers are used they should be placed below the well screen and above the bentonite pellet seal. The specific placement intervals should be decided based on site conditions.

When installing the well screen and casings through hollow-stem augers, the augers should be slowly extracted as the filter pack, bentonite pellet seal, and grout are tremied and/or poured into place. The gradual extraction of the augers will allow the materials being placed in the augers to flow out of the bottom of the augers into the borehole. If the augers are not gradually extracted, the materials (sand, pellets, etc.) will accumulate at the bottom of the augers causing potential bridging problems.

After the string of well screen and casing is plumb, the filter pack material should then be placed around the well screen to the designated depth. With cased drilling methods, the sand should be poured into the casing or augers until the lower portion is filled. The casing or augers are then withdrawn, allowing the sand to flow into the evacuated space. With hollow stem augers, sand should always fill the augers 6-12 inches, maintained by pouring the sand while checking the level with a weighted tag line. The filter pack sand in open boreholes should be installed by tremie methods, using water to wash the sand through the pipe to the point of placement.

After the filter pack has been installed, the bentonite pellet seal (if used) should be placed directly on top of the filter pack to an unhydrated thickness of two feet. When installing the seal for use with cement grouts, the bentonite pellet seal should be allowed to hydrate a minimum of eight hours or the manufacturer's recommended hydration time, whichever is longer.

After the pellet seal has hydrated for the specified time, the grout should then be pumped by the tremie method into the annular space around the casings. The grout should be allowed to set for a minimum of 24 hours before the surface pad and protective casing are installed.

After the surface pad and protective casing are installed, bumper guards should be installed (if needed). The bumper guards should be placed around the concrete surface pad in a configuration that provides maximum protection to the well. Each piece of steel pipe or approved material should be installed into an 8-to 10-inch diameter hole, to a minimum depth of 2 feet below ground surface, and filled with concrete. As previously stated, the bumper guard should extend above the ground surface a minimum of 3 feet. The total length of each bumper guard should be a minimum of 5 feet.

After the wells have been installed, the outer protective casing should be painted with a highly visible paint. The wells should be permanently marked with the well number, date installed, site name, elevation, etc., either on the cover or an appropriate place that will not be easily damaged and/or vandalized.

If the monitoring wells are installed in a high traffic area such as a parking lot, in a residential yard, or along the side of a road it may be desirable to finish the wells to the ground surface and install water-tight flush mounted traffic and/or man-hole covers. Flush mounted traffic and man-hole covers are designed to extend from the ground surface down into the concrete plug around the well casing. Although flush mounted covers may vary in design, they should have seals that make the unit water-tight when closed and secured. The flush mounted covers should be installed slightly above grade to minimize standing water and promote runoff. Permanent identification markings should be placed on the covers or in the concrete plug around the cover. Expansive sealing plugs should be used to cap the well riser to prevent infiltration of any water that might enter the flush cover.

2.4.2 Double-Cased Wells

Double-cased wells should be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross-contamination or when flowing sands make it impossible to install a monitoring well using conventional methods. A highly contaminated surface soil zone may also be cased off so that drilling may continue below the casing with reduced danger of cross contamination. A pilot borehole should be bored through the overburden and/or the contaminated zone into the clay confining layer or bedrock. An outer casing (sometimes called surface or pilot casings) should then be placed into the borehole and sealed with grout. The borehole and outer casing should extend into tight clay a minimum of two feet and into competent bedrock a minimum of 1 foot. The total depths into the clay or bedrock will vary, depending on the plasticity of the clay and the extent of weathering and\or fracturing of the bedrock. The final depths should be approved by a senior field geologist. The size of the outer casing should be of sufficient inside diameter to contain the inner casing, and the 2-inch minimum annular space. In addition, the borehole should be of sufficient size to contain the outer casing and the 2-inch minimum outer annular space, if applicable.

The outer casing should be grouted by the tremie, displacement, grout shoe, or Halliburton method from the bottom to the ground surface. The grout should be pumped into the annular space between the outer casing and the borehole wall. A minimum of 24 hours should be allowed for the grout plug (seal) to cure before attempting to drill through it. The grout mixture used to seal the outer annular space should be either a neat cement, cement/bentonite, cement/sand, or a 30% solids bentonite grout. However, the seal or plug at the bottom of the borehole and outer casing should consist of a Type I portland cement/bentonite or cement/sand mixture. The use of a pure bentonite grout for a bottom plug or seal is not acceptable, because the bentonite grout cures to a gel-like material, and is not rigid enough to withstand the stresses of drilling. When drilling through the seal, care should be taken to avoid cracking, shattering, or washing out the seal. If caving conditions exist so that the outer casing cannot be sufficiently sealed by grouting, the outer casing should be driven into place and a grout seal placed in the bottom of the casing.

2.4.2.1 Bedrock Wells

The installation of monitoring wells into bedrock can be accomplished in two ways:

1. The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock. An outer casing is then installed into the borehole by setting it into the bedrock, and grouting it into place as described in the previous section. After the grout has set, the borehole can then be advanced through the grout seal into the bedrock. The preferred method of advancing the borehole into the bedrock is rock coring. Rock coring makes a smooth, round hole through the seal and into the bedrock without cracking and/or shattering the seal. Roller cone bits are used in soft bedrock, but extreme caution should be taken when using a roller cone bit to advance through the grout seal in the bottom of the borehole because excessive water and "down" pressure can cause cracking, eroding (washing), and/or shattering of the seal. Low volume air hammers may be used to advance the borehole, but they have a tendency to shatter the seal because of the hammering action. If the structural integrity of the grout seal is in question, a pressure test can be utilized to check for leaks. A visual test can also be made by examining the cement/concrete core that is collected when the seal is cored with a diamond coring bit. If the seal leaks (detected by pressure testing) and/ or the core is cracked or shattered, or if no core is recovered because of washing, excessive down pressure, etc., the seal is not acceptable. The concern over the structural integrity of the grout seal applies to all double cased wells. Any proposed method of double casing and/or seal testing will be evaluated on its own merits, and will have to be approved by a senior field geologist before and during drilling activities, if

applicable. When the drilling is complete, the finished well will consist of an open borehole from the ground surface to the bottom of the well. There is no inner casing, and the outer surface casing, installed down into bedrock, extends above the ground surface, and also serves as the outer protective casing. If the protective casing becomes cracked or is sheared off at the ground surface, the well is open to direct contamination from the ground surface and will have to be repaired immediately or abandoned. Another limitation to the open rock well is that the entire bedrock interval serves as the monitoring zone. In this situation, it is very difficult or even impossible to monitor a specific zone, because the contaminants being monitored could be diluted to the extent of being non-detectable. The installation of open bedrock wells is generally not acceptable in the Superfund and RCRA programs, because of the uncontrolled monitoring intervals. However, some site conditions might exist, especially in cavernous limestone areas (karst topography) or in areas of highly fractured bedrock, where the installation of the filter pack and its structural integrity are questionable. Under these conditions the design of an open bedrock well may be warranted.

2. The second method of installing a monitoring well into bedrock is to install the outer surface casing and drill the borehole (by an approved method) into bedrock, and then install an inner casing and well screen with the filter pack, bentonite seal, and annular grout. The well is completed with a surface protective casing and concrete pad. This well installation method gives the flexibility of isolating the monitoring zone(s) and minimizing inter-aquifer flow. In addition, it gives structural integrity to the well, especially in unstable areas (steeply dipping shales, etc.) where the bedrock has a tendency to shift or move when disturbed. Omitting the filter pack around the well screen is a general practice in some open rock borehole installations, especially in drinking water and irrigation wells. However, without the filter pack to protect the screened interval, sediment particles from the well installation and/or from the monitoring zone could clog the well screen and/or fill the screened portion of the well rendering it inoperable. Also, the filter pack serves as a barrier between the bentonite seal and the screened interval. Rubber inflatable packers have been used to place the bentonite seal when the filter pack is omitted, but the packers have to remain in the well permanently and, over a period of time, will decompose and possibly contribute contaminants to the monitoring zone.

2.5 Well Construction Materials

2.5.1 Introduction

Well construction materials are chosen based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site(s). In this section, the different types of available materials will be discussed.

2.5.2 Well Screen and Casing Materials

When selecting the materials for well construction, the prime concern should be to select materials that will not contribute foreign constituents, or remove contaminants of concern from the ground water. If the monitoring program is designed to analyze for organic compounds, stainless steel materials are the preferred choice. If the monitoring program calls for the analyses of only inorganic compounds or the contaminants or formation are highly corrosive, then rigid PVC materials meeting National Sanitary Foundation (NSF) Standard 14 type WC (Well Casing) are acceptable. PVC materials may be acceptable for monitoring identified organic compounds in a soluble aqueous phase where incompatibilities are known to not exist. EPA document EPA/540/S-95/503, *Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation* (http://www.epa.gov/ada/-download/issue/napl.pdf) should be used for guidance in this area and in the use of PVC with non-aqueous phase liquids (NAPLs). Another concern is to select materials that will be rugged enough to endure the entire monitoring period. Site conditions will generally dictate the type of materials that can be used. A preliminary field investigation should be conducted to determine the geologic conditions, so that the most suitable materials can be selected. The best grade or highest quality material for that particular application should be selected. Each manufacturer can supply the qualitative data for each grade of material that is being considered. All materials selected for monitoring well installation should be evaluated and approved by a senior field geologist prior to field activities.

Well screen and casing materials generally used in monitoring well construction on RCRA and Superfund sites are listed in order of preference:

1. Stainless Steel (304 or 316)
2. Rigid PVC meeting NSF Standard 14 (type WC)
3. Other (where applicable)

There are other materials used for well screens and casings such as black iron, carbon steel, galvanized steel, and fiberglass, but these materials are not recommended for use in long term monitoring programs at hazardous waste sites, because of their low resistance to chemical attack and potential constituent contribution to the ground water. In cases where a driven casing is used, or a high strength outer casing is needed, carbon steel may be acceptable in non-corrosive aquifers. This outer casing should have threaded connections. Welding casing is not an acceptable practice unless all relevant safety issues have been adequately addressed.

The minimum nominal casing size for most permanent monitoring wells will be 2". Where a complete program of installation, monitoring, and abandonment is being designed, smaller wells may be installed if suitable purging and sampling equipment for the smaller diameter wells can be specified and obtained. The length of well screens in permanent monitoring wells should be long enough to effectively monitor the interval or zone of interest. However, well screens designed for long term monitoring purposes should normally not be less than 5 feet in length. Well screens less than 5 feet long are generally only used in temporary monitoring wells where ground water samples are collected for screening purposes.

2.5.3 Filter Pack Materials

The filter pack materials should consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition. The required grain-size distribution or particle sizes of the filter pack materials should be selected based upon a sieve analysis conducted on the soil samples collected from the aquifer materials and/or the formation(s) to be monitored. Filter pack materials should not be accepted unless proper documentation can be furnished as to the composition, grain-size distribution, cleaning procedure, and chemical analysis. If a data search reveals that there is enough existing data to adequately design the well screen and filter pack, then it may not be necessary to conduct a sieve analysis on the formation materials to be monitored. However, all data and design proposals will be evaluated and approved by a senior staff geologist before field activities begin.

2.5.4 Filter Pack and Well Screen Design

The majority of monitoring wells are installed in shallow ground water aquifers that consist of silts, clays, and sands in various combinations. These shallow aquifers are not generally characteristic of aquifers used for drinking water. Therefore, modifications to the procedures used for the design of water well filter packs may be required. In cases where insufficient experience exists with local or similar materials, the filter pack and well screen design should be based on the results of a sieve analysis conducted on soil samples collected from the aquifer or the formation(s) that will be monitored.

In formations consisting primarily of fines (silts and clays), the procedures for water well screen design may result in requirements for filter packs and screen slot sizes that are not available. In those cases the selection of 0.010" screen slots with a 20-40 sand filter pack, or 0.005" screen slots with 100 sand filter pack for very fine formations, will be acceptable practice. Table 6.6.1 provides size specifications for the selection of sand packs for fine formation materials. ASTM standard D5092, *Design and Installation of Ground Water Monitoring Wells in*

Aquifers, may be consulted for further guidance on specifications for sand appropriate for these applications.

Table 6.6.1
Sand Pack Specifications

Screen Opening (in)	Sand Pack Mesh Name	1% Passing Size (d-1) (in)	10% Passing Size (d-10) (in)	30% Passing Size (d-30) (in)	Derived 60% Passing Size (d-60) (in)	Range for Uniformity Coefficient
0.005-0.006	100	.0035 - .0047	.0055 - .0067	.0067 - .0083	.0085 - .0134	1.3 - 2.0
0.010"	20-40	.0098 - .0138	.0157 - .0197	.0197 -.0236	.020 - .0315	1.1 - 1.6

The following procedure should be used in coarser grained formations:

The data from the sieve analysis are plotted on a grain-size distribution graph, and a grain-size distribution curve is generated. From this grain-size distribution curve, the uniformity coefficient (Cu) of the aquifer material is determined. The Cu is the ratio of the 60 percent finer material (d60) to the 10 percent finer material (d10)

$$Cu = (d60/d10)$$

The Cu ratio is a way of grading or rating the uniformity of grain size. For example, a Cu of unity means that the individual grain sizes of the material are nearly all the same, while a Cu with a large number indicates a large range of particle sizes. As a general rule, a Cu of 2.5 or less should be used in designing the filter pack and well screen.

Before designing the filter pack and well screen, the following factors should be considered:

1. Select the well screen slot openings that will retain 90 percent of the filter pack material.
2. The filter pack material should be of the size that minimizes head losses through the pack and also prevents excessive sediment (sand, silt, clay) movement into the well.

3. A filter material of varying grain sizes is not acceptable because the smaller particles fill the spaces between the larger particles thereby reducing the void spaces and increasing resistance to flow. Therefore, filter material of the same grain size and well rounded is preferred.

4. The filter pack design is based on the gradation of the finest aquifer materials being analyzed.

Steps to design a filter pack in aquifers:

1. Construct a grain-size distribution curve, on a grain-size distribution graph, from the sieve analysis of the aquifer materials. The filter pack design (as stated above) is based on the gradation of the finest aquifer materials.

2. Multiply the d30 size from the grain-size distribution graph by a factor of four to nine (Pack-Aquifer ratio). A factor of four is used if the formation is fine-grained and uniform (Cu is less than 3), six if it is coarse-grained and non-uniform, and up to nine if it is highly non-uniform and contains silt. Head losses through filter packs increase as the Pack-Aquifer (P-A) ratios decrease. In order to design a fairly stable filter pack with a minimum head loss, the d30 size should be multiplied by a factor of four.

3. Plot the point from step 2 on the d30 abscissa of a grain-size distribution graph and draw a smooth curve with a uniformity coefficient of approximately 2.5.

4. A curve for the permissible limits of the filter pack is drawn plus or minus 8 per cent of the desired curve with the Cu of 2.5.

5. Select the slot openings for the well screen that will retain 90 per cent or more of the filter pack material.

The specific steps and procedures for sieve analysis and filter pack design can be found in soil mechanics, ground water, and water well design books. The staff geologists and/or engineers should be responsible for the correct design of the monitoring wells and should be able to perform the design procedures.

2.6 Safety Procedures for Drilling Activities

A site health and safety plan should be developed and approved by the Branch Safety Officer or designee prior to any drilling activities, and should be followed during all drilling activities. The driller or designated safety person should be responsible for the safety of the drilling team performing the drilling activities. All personnel conducting drilling activities should be qualified in proper drilling and safety procedures. Before any drilling activity is initiated, utilities should be marked or cleared by the appropriate state or municipal utility protection organization. In developed areas, additional measures should be taken to locate utilities not covered by the utility protection program. Before operating the drill rig, a pilot hole should be dug (with hand equipment) to a depth of three feet to check for undetected utilities or buried objects. Proceed with caution until a safe depth is reached where utilities normally would not be buried. The following safety requirements should be adhered to while performing drilling activities:

1. All drilling personnel should wear safety hats, safety glasses, and steel toed boots. Ear plugs are required and will be provided by the safety officer or driller.

2. Work gloves (cotton, leather, etc.) should be worn when working around or while handling drilling equipment.

3. All personnel directly involved with the drilling rig(s) should know where the kill switch(s) is located in case of emergencies.

4. All personnel should stay clear of the drill rods or augers while in motion, and should not grab or attempt to attach a tool to the drill rods or augers until they have completely stopped rotating. Rod wipers, rather than gloves or bare hands should be used to remove mud, or other material, from drill stem as it is withdrawn from the borehole.

5. Do not hold drill rods or any part of the safety hammer assembly while taking standard penetration tests or while the hammer is being operated.

6. Do not lean against the drill rig or place hands on or near moving parts at the rear of the rig while it is operating.

7. Keep the drilling area clear of any excess debris, tools, or drilling equipment.

8. The driller will direct all drilling activities. No work on the rig or work on the drill site will be conducted outside of the driller’s direction. Overall drill site activities will be in consultation with the site geologist or engineer, if present.

9. Each drill rig will have a first-aid kit and a fire extinguisher located on the rig in a location quickly accessible for emergencies. All drilling personnel will be familiarized with their location.

10. Work clothes will be firm fitting, but comfortable and free of straps, loose ends, strings etc., that might catch on some moving part of the drill rig.

11. Rings, watches, or other jewelry will not be worn while working around the drill rig.

12. The drill rig should not be operated within a minimum distance of 20 feet of overhead electrical power lines and/or buried utilities that might cause a safety hazard. In addition, the drill rig should not be operated while there is lightening in the area of the drilling site. If an electrical storm moves in during drilling activities, the area will be vacated until it is safe to return.

2.7 Well Development

A newly completed monitoring well should not be developed for at least 24 hours after the surface pad and outer protective casing are installed. This will allow sufficient time for the well materials to cure before development procedures are initiated. The main purpose of developing new monitoring wells is to remove the residual materials remaining in the wells after installation has been completed, and to try to re-establish the natural hydraulic flow conditions of the formations which may have been disturbed by well construction, around the immediate vicinity of each well. A new monitoring well should be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In most cases the above requirements can be satisfied; however, in some cases the pH, temperature, and specific conductivity may stabilize but the water remains turbid. In this case the well may still contain well construction materials, such as drilling mud in the form of a mud cake and/or formation soils that have not been washed out of the borehole. Excessive or thick drilling mud cannot be flushed out of a borehole with one or two well volumes of flushing. Continuous flushing over a period of several days may be necessary to complete the well development. If the well is pumped to dryness or near dryness, the water table should be allowed to sufficiently recover (to the static water level) before the next development period is initiated. Caution should be taken when using high rate pumps and/or large volume air compressors during well development because excessive high rate pumping and high air pressures can damage or destroy the well screen and filter pack. The onsite geologist should make the decision as to the development completion of each well. All field decisions should be documented in the field log book.

The following development procedures, listed in approximate increasing order of the energy applied to the formation materials, are generally used to develop wells:

1. Bailing
2. Pumping/overpumping
3. Surging
4. Backwashing ("rawhiding")
5. Jetting
6. Compressed air (with appropriate filtering): airlift pumping and air surging

These development procedures can be used, individually or in combination, in order to achieve the most effective well development. In most cases, over-pumping and surging will adequately develop the well without imparting undue forces on the formation or well materials. Except when compressed air is being used for well development, sampling can be initiated as soon as the ground water has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, even between wells, a general rule-of-thumb is to wait 24 hours after development to sample a new monitoring well. Wells developed with stressful measures may require as long as a 7-day interval before sampling. In particular, air surge developed wells require 48 hours or longer after development so that the formation can dispel the compressed air and re-stabilize to pre-well construction conditions. Because of the danger of introducing contaminants with the airstream, the possibility of entraining air in the aquifer, and the violent forces imparted to the formation, air surging is the least desired method of development and should only be used where there is a specific need for the procedure. Air-lift pumping is permissible where an eductor pipe is used and several well volumes of water are removed from the well by other by pumping means after air-lift pumping. The selected development method(s) should be approved by a senior field geologist before any well installation activities are initiated.

2.8 Well Decommisioning (Abandonment)

When a decision is made to decommission (abandon) a monitoring well, the borehole should be sealed in such a manner that the well cannot act as a conduit for migration of contaminants from the ground surface to the water table or between aquifers. To properly decommission a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete. In order to comply with state well decommissioning requirements, the appropriate state agency should be notified (if applicable) of monitoring well decommissioning. However, some state requirements are not explicit, so a technically sound well abandonment method should be designed based on the site geology, well casing materials, and general condition of the well(s).

2.8.1 Decommissioning Procedures

As previously stated the preferred method should be to completely remove the well casing and screen from the borehole. This may be accomplished by augering with a hollow-stem auger over the well casing down to the bottom of the borehole, thereby removing the grout and filter pack materials from the hole. The well casing should then be removed from the hole with the drill rig. The clean borehole can then be backfilled with the appropriate grout material. The backfill material should be placed into the borehole from the bottom to the top by pressure grouting with the positive displacement method (tremie method). This abandonment method can be accomplished on small diameter (1-inch to 4-inch) wells without too much difficulty. With wells having 6-inch or larger diameters, the use of hollow-stem augers for casing removal is very difficult or almost impossible. Instead of trying to ream the borehole with a hollow-stem auger, it is more practical to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and extract it out of the borehole. Wells with little or no grouted annular space and/or sound well casings can be removed in this manner. However, old wells with badly corroded casings and/or thickly grouted annular space have a tendency to twist and/or break-off in the borehole. When this occurs, the well will have to be grouted with the remaining casing left in the borehole. The preferred method in this case should be to pressure grout the borehole by placing the tremie tube to the bottom of the well casing, which will be the well screen or the bottom sump area below the well screen. The pressurized grout will be forced out through the well screen into the filter material and up the inside of the well casing sealing holes and breaks that are present.

A PVC well casing may be more difficult to remove from the borehole than a metal casing, because of its brittleness. If the PVC well casing breaks during removal, the borehole should be cleaned out by using a drag bit or roller cone bit with the wet rotary method to grind the casing into small cuttings that will be flushed out of the borehole by water or drilling mud. Another method is to use a solid-stem auger with a carbide tooth pilot bit to grind the PVC casing into small cuttings that will be brought to the surface on the rotating flights. After the casing materials have been removed from the borehole, the borehole should be cleaned out and pressure grouted with the approved grouting materials.

Where state regulations and conditions permit, it may be permissible to grout the casing in place. This decision should be based on confidence in the original well construction practice, protection of drinking water aquifers, and anticipated future property uses. The pad should be demolished and the area around the casing excavated. The casing should be sawn off at a depth of three feet below ground surface. The screen and riser should be tremie grouted with a 30% solids bentonite grout in the saturated zone. The remaining riser may be grouted with a cement grout for long term resistance to desiccation.

3 Temporary Monitoring Well Installation

3.1 Introduction

Five types of temporary monitoring well installation techniques have been demonstrated as acceptable. The type selected for a particular site is dependent upon site conditions. The project leader and site geologist should be prepared to test temporary well installations on site and select the best solution. Temporary wells are cost effective, may be installed quickly, and provide a synoptic picture of ground water quality.

Temporary monitoring well locations are not permanently marked, nor are their elevations normally determined. Sand pack materials may or may not be used, but typically there is no bentonite seal, grout, surface completion, or extensive development (as it normally applies to permanent monitoring wells). Temporary wells are generally installed, purged, sampled, removed, and backfilled in a matter of hours.

Due to the nature of construction, turbidity levels may initially be high. However, these levels may be reduced by low flow purging and sampling techniques as described in Section 7.2.4.

Temporary wells may be left overnight, for sampling the following day, but the well must be secured, both against tampering and against the fall hazard of the open annulus. If the well is not sampled immediately after construction, the well should be purged prior to sampling as specified in SESD Operating Procedure for Groundwater Sampling, SESDPROC-301.

3.2 Data Limitation

Temporary wells described in this section are best used for delineation of contaminant plumes at a point in time, and for some site screening purposes. They are not intended to replace permanent monitoring wells. Temporary wells can be used in conjunction with a mobile laboratory, where quick analytical results can be used to delineate contaminant plumes.

3.3 Temporary Well Materials

Materials used in construction of temporary monitoring wells are the same standard materials used in the construction of permanent monitoring wells. Sand used for the filter pack (if any) should be as specified in Section 2.5.3, Filter Pack Materials. The well screen and casing should be stainless steel for ruggedness and suitability for steam cleaning and solvent rinsing. Other materials may be acceptable, on a case by case basis. Some commercially available temporary well materials, pre-packed riser, screen and filter pack assemblies are available commercially; however, these pre-assembled materials cannot be cleaned. Appropriate QA/QC must be performed to assure there will be no introduction of contamination.

3.4 Temporary Monitoring Well Borehole Construction

Borehole construction for temporary wells is as specified in Section 2.3, using a drill rig. Alternatively, boreholes may be constructed using hand augers or portable powered augers (generally limited to depths of ten feet or less). If a drill rig is used to advance the borehole, the augers must be pulled back the length of the well screen (or removed completely) prior to sampling. When hand augers are used, the borehole is advanced to the desired depth (or to the point where borehole collapse occurs). In situations where borehole collapse occurs, the auger bucket is typically left in the hole at the point of collapse while the temporary well is assembled. When the well is completely assembled, a final auger bucket of material is quickly removed and the well is immediately inserted into the borehole, pushing, as needed, to achieve maximum penetration into the saturated materials.

3.5 Temporary Monitoring Well Types

Five types of monitoring wells which have been shown to be acceptable are presented in the order of increasing difficulty to install and increasing cost:

3.5.1 No Filter Pack

This is the most common temporary well and is very effective in many situations. After the borehole is completed, the casing and screen are simply inserted. This is the least expensive and fastest well to install. This type of well is extremely sensitive to turbidity fluctuations because there is no filter pack. Care should be taken to not disturb the casing during purging and sampling.

3.5.2 Inner Filter Pack

This type differs from the "No Filter Pack" well in that a filter pack is placed inside the screen to a level approximately 6 inches above the well screen. This ensures that all water within the casing has passed through the filter pack. For this type well to function properly, the static water level must be at least 6-12 inches above the filter pack. The screen slots may plug in some clayey environments with this construction method and others that use sand only inside the well screen.

3.5.3 Traditional Filter Pack

For this type of well, the screen and casing are inserted into the borehole, and the sand is poured into the annular space surrounding the screen and casing. Occasionally, it may be difficult to effectively place a filter pack around shallow open boreholes, due to collapse. This method requires more sand than the "inner filter pack" well, increasing material costs. As the filter pack is placed, it mixes with the muddy water in the borehole, which may increase the amount of time needed to purge the well to an acceptable level of turbidity.

3.5.4 Double Filter Pack

The borehole is advanced to the desired depth. As with the "inner filter pack" the well screen is filled with filter pack material and the well screen and casing inserted until the top of the filter pack is at least 6 inches below the water table. Filter pack material is poured into the annular space around the well screen. This type temporary well construction can be effective in aquifers where fine silts or clays predominate. This construction technique takes longer to implement and uses more filter pack material than others previously discussed.

3.5.5 Well-in-a-Well

The borehole is advanced to the desired depth. At this point, a 1-inch well screen and sufficient riser is inserted into a 2-inch well screen with sufficient riser, and centered. Filter pack material is then placed into the annular space surrounding the 1-inch well screen, to approximately 6 inches above the screen. The well is then inserted into the borehole.

This system requires twice as much well screen and riser, with attendant increases in assembly and installation time. The increased amount of well construction materials results in a corresponding increase in decontamination time and costs. The use of pre-packed well screens in this application will require rinse blanks of each batch of screens. Pre-pack Screen assemblies cannot be decontaminated for reuse.

3.6 Decommissioning

Temporary well boreholes must be decommissioned after sampling and removal of the screen and riser. Backfilling the holes with cuttings may be acceptable practice for shallow holes in uniform materials with expected low contamination levels. Use of cuttings would not be an acceptable practice if waste materials were encountered or a confining layer was breached. Likewise, where the borehole is adjacent to, or downgradient of contaminated areas, the loose backfilled material could create a highly permeable conduit for contaminant migration. If the borehole will not be backfilled with the soil cuttings for this or other reasons, then SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, should be referenced regarding disposal of the cuttings as IDW.

4 Temporary Monitoring Well Installation Using the Geoprobe® Screen Point 15/16 Groundwater Sampler

4.1 Introduction

The Geoprobe® Screen Point 15/16 Groundwater Sampler is a discrete interval ground water sampling device that can be pushed to pre-selected sampling depths in saturated, unconsolidated materials. Once the target depth has been reached, the screen is opened and groundwater can be sampled as a temporary monitoring well, which yields a representative, uncompromised sample from that depth. Using knock-out plugs, this method also allows for grouting of the push hole during sample tool retrieval.

The Screen Point® 15 sampler consist of four parts (drive point, screen, sampler sheath and drive head), with an assembled length of 52 inches (1321 mm) and a maximum OD of 1.5 inches (38 mm). When opened, it has an exposed screen length of 41 inches (1041 mm). It is typically pushed using 1.25-inch probe rod. The Screen Point® 16 consists of the same parts and works in the same fashion, the only differences being larger diameter and its use with 1.5” rods.

4.1.1 Assembly of Screen Point® 15/16 Groundwater Sampler

1. Install O-ring on expendable point and firmly seat in the angled end of the sampler sheath.

2. Place a grout plug in the lower end of the screen section. Grout plug material should be chosen with consideration for site specific Data Quality Objectives (DQOs).

3. When using stainless steel screen, place another O-ring* in the groove on the upper end of the screen and slide it into the sampler sheath.

4. Place an O-ring* on the bottom of the drive head and thread into the top of the sampler sheath.

5. The Screen Point® 15/16 Groundwater Sampler is now assembled and ready to push for sample collection.

* It should be noted that O-ring use in steps 3 and 4 are optional.

4.1.2 Installation of Screen Point® 15/16 Groundwater Sampler

1. Attach drive cap to top of sampler and slowly drive it into the ground. Raise the hammer assembly, remove the drive cap and place an O-ring* in the top groove of the drive head. Add a probe rod and continue to push the rod string.

2. Continue to add probe rods until the desired sampling depth is reached.

3. When the desired sampling depth is reached, re-position the probe derrick and position either the casing puller assembly or the rod grip puller over the top of the top probe rod.

4. Thread a screen push adapter on an extension rod and attach sufficient additional extension rods to reach the top of the Screen Point® 15/16 sampler. Add an extension handle to the top of the string of extension rods and run this into the probe rod, resting the screen push adapter on top of the sampler.

5. To expose the screened portion of the sampler, exert downward pressure on the sampler, using the extension rod and push adapter, while pulling the probe rod upward. To expose the entire open portion of the screen, pull the probe rod upward approximately 41 inches.

6. At this point, the Screen Point® 15/16 Groundwater Sampler has been installed as a temporary well and may be sampled using appropriate ground water sampling methodology. If waters levels are less than approximately 25 feet, EIB personnel typically use a peristaltic pump, utilizing low-flow methods, to collect ground water samples from these installations. If water levels are greater than 25 feet, a manual bladder pump, a micro bailer, or other method may have to be utilized to collect the sample (SESD Operating Procedure for Groundwater Sampling, SESDPROC-301-R0) provides detailed descriptions of these techniques and methods).

4.1.3 Special Considerations for Screen Point® 15/16 Installations

<u>Decommissioning (Abandonment)</u>

In many applications, it may be appropriate to grout the abandoned probe hole where a Screen Point® 15/16 sampler was installed. This probe hole decommissioning can be accomplished through two methods which are determined by location and contamination risk. In certain non-critical areas, boreholes may be decommissioned by filling the saturated zone with bentonite pellets and grouting the vadose zone with neat cement poured from the surface or Bentonite pellets properly hydrated in place. Probe holes in areas where poor borehole sealing could present a risk of contaminant migration should be decommissioned by pressure grouting through the probe rod during sampler retrieval. To accomplish this, the grout plug is knocked out of the bottom of the screen using a grout plug push adapter and a grout nozzle is fed through the probe rod, extending just below the bottom of the screen. As the probe rod and sampler are pulled, grout is injected in the open hole below the screen at a rate that just fills the open hole created by the pull. Alternatively, the screen can generally be pulled and the hole re-probed with a tool string to be used for through-the-rod grouting.

Screen Material Selection

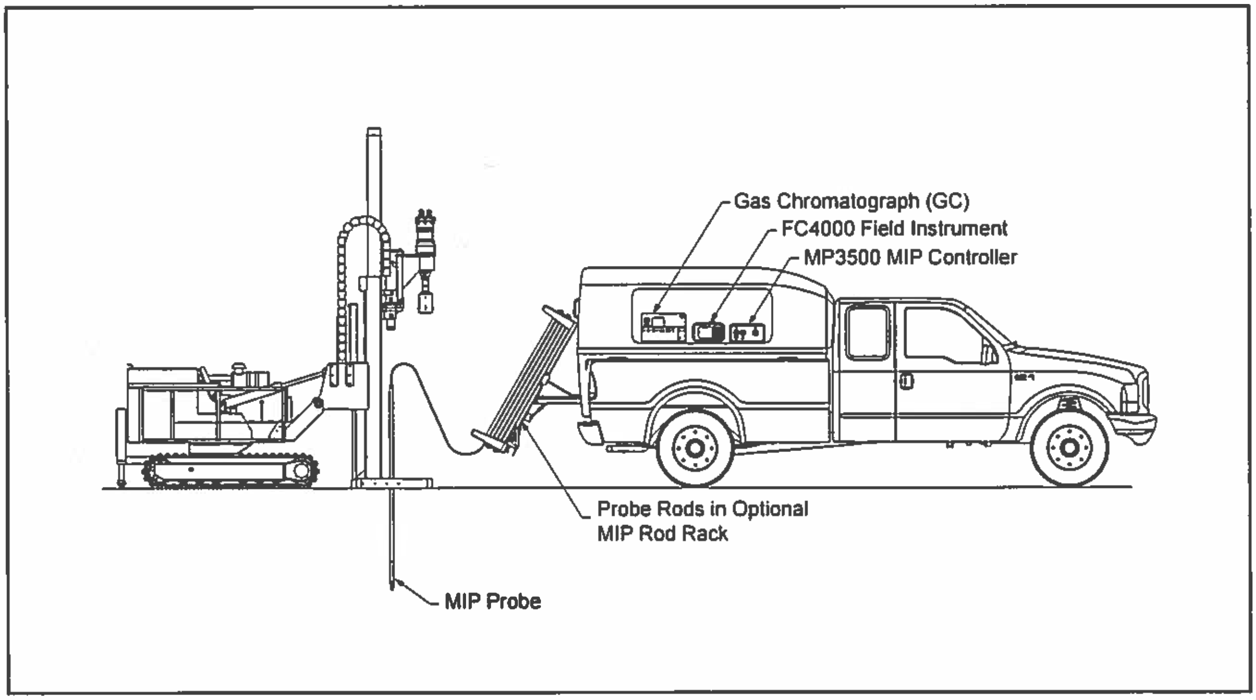
Screen selection is also a consideration in sampling with the Screen Point® 15/16 sampler. The screens are available in two materials, stainless steel and PVC. Because of stainless steel's durability, ability to be cleaned and re-used, and overall inertness and compatibility with most contaminants, it is the material typically used during EIB investigations.

GEOPROBE® MEMBRANE INTERFACE PROBE (MIP)

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3010

PREPARED: May, 2003
REVISED: August, 2006



THE MIP SYSTEM MAY BE DEDICATED TO A SINGLE CARRIER VEHICLE FOR USE IN TANDEM WITH MULTIPLE GEOPROBE® DIRECT PUSH MACHINE MODELS

Geoprobe Systems®
A DIVISION OF KEJR, INC.

Geoprobe Systems®

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1.0 OBJECTIVE

This document serves as the standard operating procedure for use of the Geoprobe Systems® Membrane Interface Probe (MIP) to detect volatile organic compounds (VOCs) at depth in the subsurface.

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically-powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and testing, soil conductivity and contaminant logging, grouting, and materials injection.
**Geoprobe® is a registered trademark of Kejr, Inc., Salina, Kansas.*

Membrane Interface Probe (MIP): A system manufactured by Geoprobe Systems® for the detection and measurement of volatile organic compounds (VOCs) in the subsurface. A heated probe carrying a permeable membrane is advanced to depth in the soil. VOCs in the subsurface cross the membrane, enter into a carrier gas stream, and are swept to gas phase detectors at ground surface for measurement.

2.2 Discussion

The MIP is an interface between contaminates in the soil and the detectors at ground surface. It is a screening tool used to find the depth at which the contamination is located, but is not used to determine concentration of the compound. Two advantages of using the MIP are that it detects contamination in situ and can be used in all types of soil conditions.

Refer to Figure 2.1. The MIP is a logging tool used to make continuous measurements of VOCs in soil. Volatile compounds outside the probe diffuse across a membrane and are swept from the probe to a gas phase detector at ground surface. A log is made of detector response with probe depth. In order to speed diffusion, the probe membrane is heated to approximately 100° C (212° F).

Along with the detection of VOCs in the soil, the MIP also measures the electrical conductivity of the soil to give a probable lithology of the subsurface. This is accomplished by using a dipole measurement arrangement at the end of the MIP probe so that both conductivity and detector readings may be taken simultaneously. A simultaneous log of soil conductivity is recorded with the detector response.

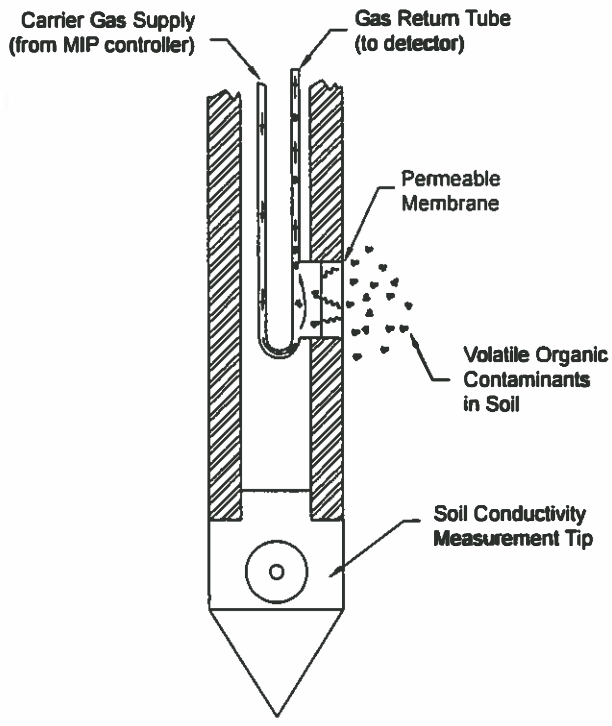


Figure 2.1
Schematic drawing of the MIP probe

3.0 Tools and Equipment

The following equipment is needed to perform and record an MIP log. Basic MIP system components are listed in this section and illustrated in Figure 3.1. Refer also to Appendix I for more required tools as determined by your specific model of Geoprobe® direct push machine.

3.1 Basic MIP System Components

Description	Quantity	Part Number
Field Instrument	(1)	FC4000 / FC5000
MIP Controller	(1)	MP3500 / MP6500
MIP/EC Acquisition Software	(1)	MP3517
MIP Probe	(1)	MP4510 / MP6510
Replacement Membrane	(1)	MP3512
Membrane Wrench	(1)	16172
LB Sample Tube	(1)	AT6621
Stringpot (linear position transducer)	(1)	SC160
Stringpot Cordset	(1)	SC161
MIP O-ring and Service Kit	(1)	MP2515
MIP Trunkline, 100-ft (30 m) length	(1)	MP2550
Extension Cord, 25-ft (8 m) length	(1)	SC153
Needle Valve	(1)	13700
24-in. Nafion Dryer Tube	(1)	12457
Drive Cushion*	(1)	23321

3.2 Anchoring Equipment

Description	Quantity	Part Number
Soil Anchor, 4.0-in. OD flight	(3)	10245
Anchor Foot Bridge	(1)	10824
Anchor Plate	(3)	10167
GH60 Hex Adapter (if applicable)	(1)	10809
Chain Vise	(3)	10075

3.3 Optional Accessories

Description	Quantity	Part Number
MIP Trunkline, 150-ft (46 m) length	(1)	13999
MIP Trunkline, 200-ft (61 m) length	(1)	15698
FID Compressed Air System	(1)	AT1004
Hydrogen Gas Regulator	(1)	10344
Nitrogen Gas Regulator	(1)	13940
Cable Rod Rack, for 48-in. rods	(1)	18355
Rod Cart Assembly, for 1.25-in. OD rods	(1)	SC610
Rod Cart Hitch Rack, for SC610	(1)	SC650K
Rod Cart Carrier, for SC610	(1)	SC675
Rod Wiper, for 5400 Series foot	(1)	AT1255
Rod Wiper, for 66 Series foot	(1)	18181
Rod Grip Pull Handle, for GH40 hammer	(1)	GH1255
Rod Grip Pull Handle, for GH60 hammer	(1)	9641
Water Transport System	(1)	19011

*For Geoprobe® 66- and 77-Series Direct Push Machines only.

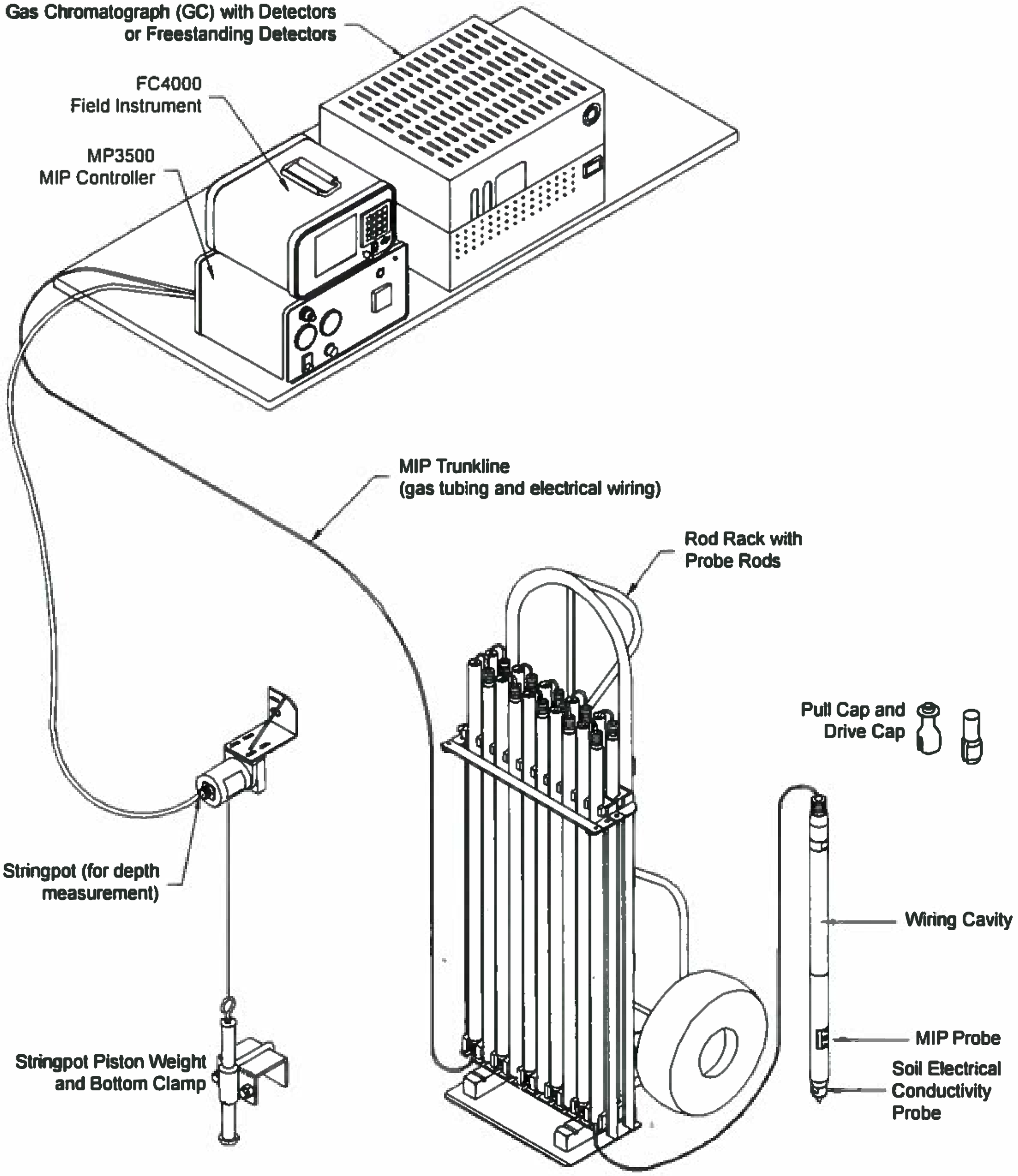


Figure 3.1
MIP system components

4.0: Quality Control - Response Testing

Response testing is an important quality control measure used to validate each log by proving that the integrity of the system is intact. Without running a response test, the operator will not know if the system is detecting the correct compounds or even if the system is working.

4.1 Preparation for Response Testing

Response testing is a necessary part of the MIP logging process because it ensures that the entire system is working correctly and also enables the operator to measure the trip time. Trip time is the time it takes for the contaminant to go from the probe, through the trunk line, and to the detectors. This time will need to be entered into the MIP software for depth calculations as described later in this document.

The following items are required to perform response testing:

- Neat sample of the analyte of interest (i.e.: benzene, TCE, PCE, etc.) purchased from chemical vendor
- Microliter syringes
- 25- or 50-mL Graduated cylinder
- Several 40-mL VOC vials with labels
- Testing cylinder made from a nominal 2-in. PVC pipe with a length of 24 in.
- 0.5 L plastic beaker or pitcher
- 25 mL Methanol
- Supply of fresh water, 0.5 L needed per test
- 5-gallon bucket filled with fine sand and water
- Stopwatch

Preparation of the stock standard is critical to the final outcome of the concentration to be placed into the testing cylinder.

1. Pour methanol into graduated cylinder to the 25 mL mark.

2. Pour 25 mL of methanol from graduated cylinder into 40-mL VOC vial.

3. Mix appropriate volume of desired neat analyte into 40-mL VOC vial containing 25 mL of methanol. The required volume of neat analyte for five common compounds is listed in Column 3 of Table 4.1. Use the equation at the then of this section to calculate the appropriate neat analyte volume for other compounds of interest.

4. Label the vial with name of standard (i.e. TCE, PCE, Benzene), concentration (50 mg/mL), date created, and created by (your name). This is the Stock Standard.

The equation used for making a stock standard is shown on the following page.

Table 4.1
Density and required volumes of neat compounds used to make a 50 mg/mL working standard into 25 ml of methanol

Compound	Density (mg/uL)	Volume of Neat Analyte Required to Prepare a Working Standard (uL)
Benzene	0.8765	1426
Toluene	0.8669	1442
Carbon Tetrachloride	1.594	784
PCE	1.6227	770
TCE	1.4642	854

25 mL (methanol) x 50 mg/mL = 1250 mg
1250 mg x 1/density of analyte = amount of neat material to be placed into 25 mL of Methanol

Example: Preparation of 50 mg/mL Benzene standard.
1250 mg x 1/0.8765 mg/uL = 1426 uL
Use 1426 uL of neat Benzene in 25 mL of Methanol to get a 50 mg/mL standard.

4.2 Response Test Procedure

With the standard prepared, the operator is ready to test the response of the probe as described below.

1. Stabilize the baseline by immersing the probe in a container with enough water to fully cover the membrane. This is necessary due to the sensitivity of the photoionization detector (PID) and the electron capture detector (ECD) to oxygen.

2. Access the MIP Time software and view the detector vs. time data. The detector signals should be stable before proceeding.

3. Obtain 500 mL of water (either tap water or distilled) in a suitable measuring container.

Table 4.2
Volume of 50 mg/mL working standard and final concentration in 0.5 L test sample volume

Volume of 50 mg/mL Standard	Final Concentration of 0.5 L Sample (mg/L or ppm)
1000 uL	100
100 uL	10
10 uL	1

4. Use a standard volume specified in Table 4.2 to mix the desired test concentration. This is the Working Standard.

5. Pour the working standard into a nominal 2-inch x 24-inch PVC pipe and immediately insert the MIP into the solution (Fig. 4.1). Leave the probe in the test solution for 45 seconds. At the end of 45 seconds, place the probe back in the container of water.

6. From the results on the MIP Time software the trip time and response time can both be measured (Fig. 4.2).

Figure 4.1
The MIP probe is placed in a PVC pipe containing the standard solution.

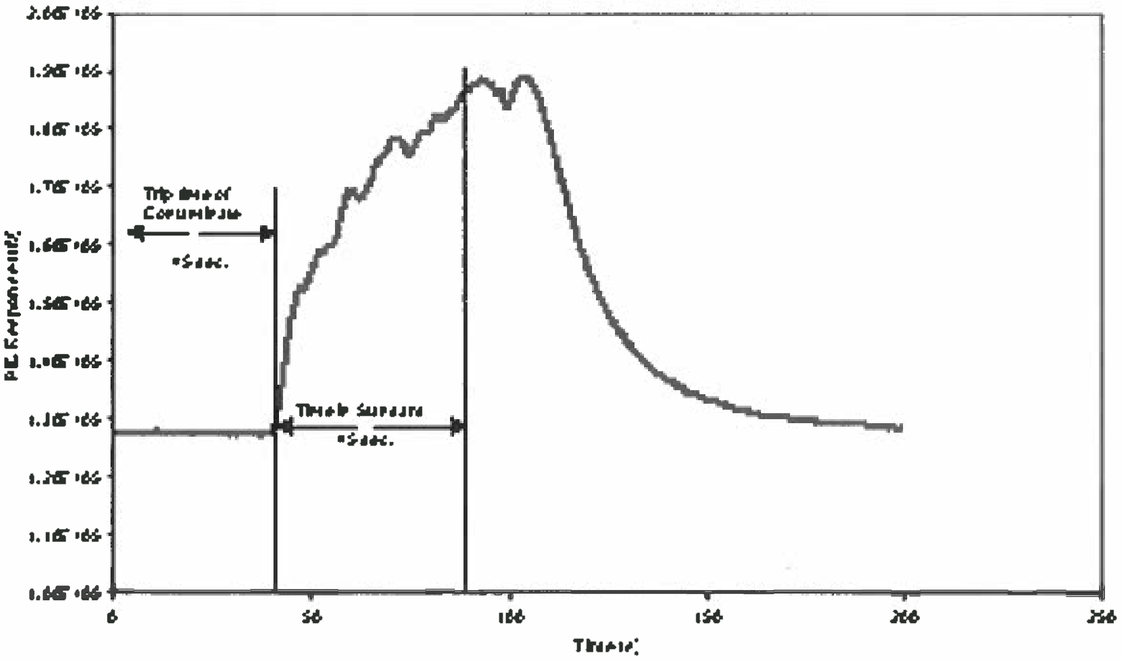


Figure 4.2
SRI PID Response Test - 10 ppm Benzene

5.0 Field Operation

1. Power on the generator.
2. Turn on any gases that will be used for the MIP system (i.e. nitrogen carrier gas, hydrogen for the FID, etc.). Check the flow rate of the system and psi on the mass flow controller. Compare these numbers to previous work.
3. Power on the detector or detectors and allow to warm up to set temperature (approximately 30 minutes).
4. Power on the MIP Controller.
5. Power on the computer or the Field Instrument.
6. Advance a pre-probe 3 to 4 feet into the subsurface at the location to be logged.
7. Remove the pre-probe and raise the probe foot of the direct push machine.
8. If advancing the MIP with percussion, raise the probe foot enough to slide the rod wiper plate underneath.
9. If pushing only, turn the desired amount of anchors into the subsurface and return the probe foot to the position from which the pre-probe was advanced. Leave the probe foot raised sufficiently to allow sliding the rod wiper underneath.
10. Place the rod wiper plate under the foot such that the opening is directly over the pre-probed hole. Lower the foot firmly onto the rod wiper.

11. If pushing only, position the anchoring bridge over the foot of the machine such that the anchors extend through the holes in the bridge (fig. 5.1). Install a chain vise at each anchor to secure the bridge.
12. With the software loaded, run a response test (Section 4.0) and record the height of the peak response and the trip time into a field notebook. Refer to Figure 4.2.
13. Enter the trip time obtained during response testing.
14. Attach a slotted drive cap to the MIP drive head.
15. Insert the MIP point into rod wiper opening and drive it into the soil until the membrane of the probe is at ground level.
16. Connect the stringpot cable to the stringpot weight located on the probe foot and pull keeper pin so the weight drops to the ground.

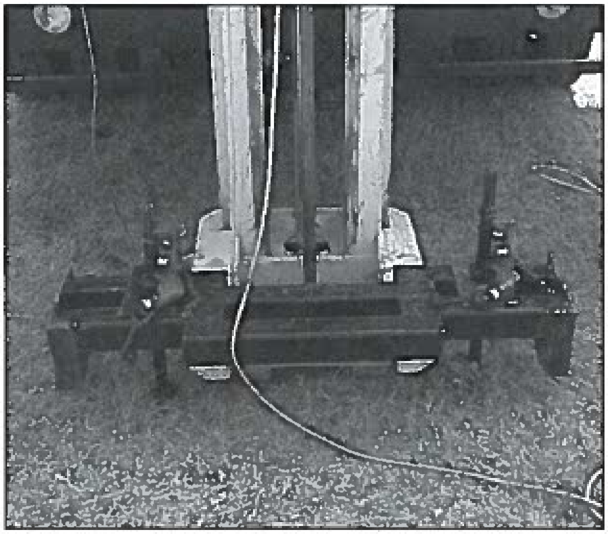


Figure 5.1
Anchor the probe foot to allow advancement of MIP probe by push only (no percussion).

NOTE: Do not allow the stringpot cable to retract into the stringpot housing at a high rate. This will ultimately damage the stringpot.

17. Record the system parameters in a field notebook at this time (i.e.. mass flow, trip time).

NOTE: If the mass flow reading drops or rises more than one psi, turn off the flow at the primary controller and remove the probe from the ground. If the temperature monitor quits heating or gives an error, remove the probe from the ground.

18. Place the trigger switch in the "ON" position.
19. Advance the probe at a rate of 1 ft/min to the predetermined log depth or until refusal is attained.

NOTE: Refusal is attained when it takes longer than 1.5 minutes of continuous hammering to advance the probe one foot. This is the maximum time to reach one foot of probe travel.

20. When the MIP log is complete, turn the trigger off and slowly return the stringpot cable into the stringpot housing.
21. Pull the probe rod string using either the Geoprobe® rod grip pull system or a slotted pull cap.
22. When the MIP reaches the surface, clean the face with water and run a response test. This response test should be written down in the field notes and compared to the initial test. This system check ensures the data for that log is valid.
23. Save the data to a 3.5-inch floppy disk or CompactFlash® card and exit the MIP software.
24. Data from the MIP can now be graphed with Direct Image® MIP Display Log or imported into any spreadsheet for graphing.

6.0 Replacing a Membrane on the MIP Probe

A probe membrane is considered in good working condition as long as two requirements are met: 1) The butane sanity test result is greater than 1.0E+06 uV response, 2) Flow of the system has not varied more than 3 mL/min from the original flow of the system (a flow meter or bubble flow meter should be kept with the system at all times). If either one of these requirements are not met, a new face must be installed as follows.

1. Turn the heater off and allow the block to cool to less than 50° C on the control panel readout.
2. Clean the entire heating block with water and a clean rag to remove any debris.
3. Dry the block completely before proceeding.
4. Remove the membrane using the membrane wrench (Fig. 6.1). Keep the wrench parallel to the probe while removing the membrane to ensure proper engagement with socket head cap screw.

NOTE: Do Not leave the membrane cavity open for extended periods. Debris can become lodged in the gas openings in the plug.

5. Remove and discard the copper washer as shown in Figure 6.2. Each new membrane is accompanied by a new copper washer. **Do not reuse the copper washer.**
6. Inspect the open cavity for any foreign objects. Remove any objects present and clean the inside of cavity of any soil that was deposited on the wall of the block.
7. Insert the new copper washer around the brass plug making sure that it sits flat on the surface of the block.
8. Install the new membrane by threading it into the socket. Use the membrane wrench to tighten the membrane to a snug fit. Do not overtighten.
9. Turn the gas on and leave the heater off. Apply water to the membrane and surrounding area to check for leaks. If a leak is detected (bubbles are formed in the water), use the membrane wrench to further tighten the membrane.
10. Use a flow meter/bubble flow meter to check flow to the detectors. Record this value in a field notebook.

Figure 6.1
Unthread the membrane from the probe block.

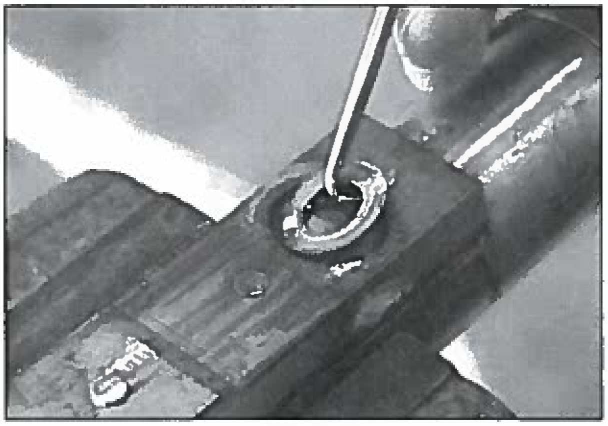


Figure 6.2
Remove and discard the copper washer.

Appendix I: Tools for Various Direct Push Machines

Model 5400 and 54DT Direct Push Machines

Description	*Part Number*
Stringpot Mounting Bracket	SC110
Stringpot Bottom Clamp	SC111
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 54LT Direct Push Machine

Description	*Part Number*
Stringpot Mounting Bracket	11433
Stringpot Bottom Clamp	SC111
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 5410 Direct Push Machine

Description	*Part Number*
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.25-in. rods	AT1202
Slotted Pull Cap, for 1.25-in. rods	AT1203
MIP Drive Adapter, for 1.25-in. rods	MP2512
MIP Drive Head	GW1516
Probe Rod, 1.25-in. x 48-in.	AT1248

Model 6600, 66DT and 6610DT Direct Push Machines

Description	*Part Number*
Stringpot Mounting Bracket	16971
Stringpot Bottom Clamp	11751
Stringpot Piston Weight	SC112
Slotted Drive Cap, for 1.5-in. rods	15607
Slotted Pull Cap, for 1.5-in. rods	15164
Drive Cap Adapter, for GH60 and 1.25-in. rods	15498
MIP Drive Adapter, for 1.5-in. rods	18563
MIP Friction Reducer	18564
Probe Rod, 1.5-in. x 48-in.	13359

Geoprobe Systems®

A DIVISION OF KEJR, INC.

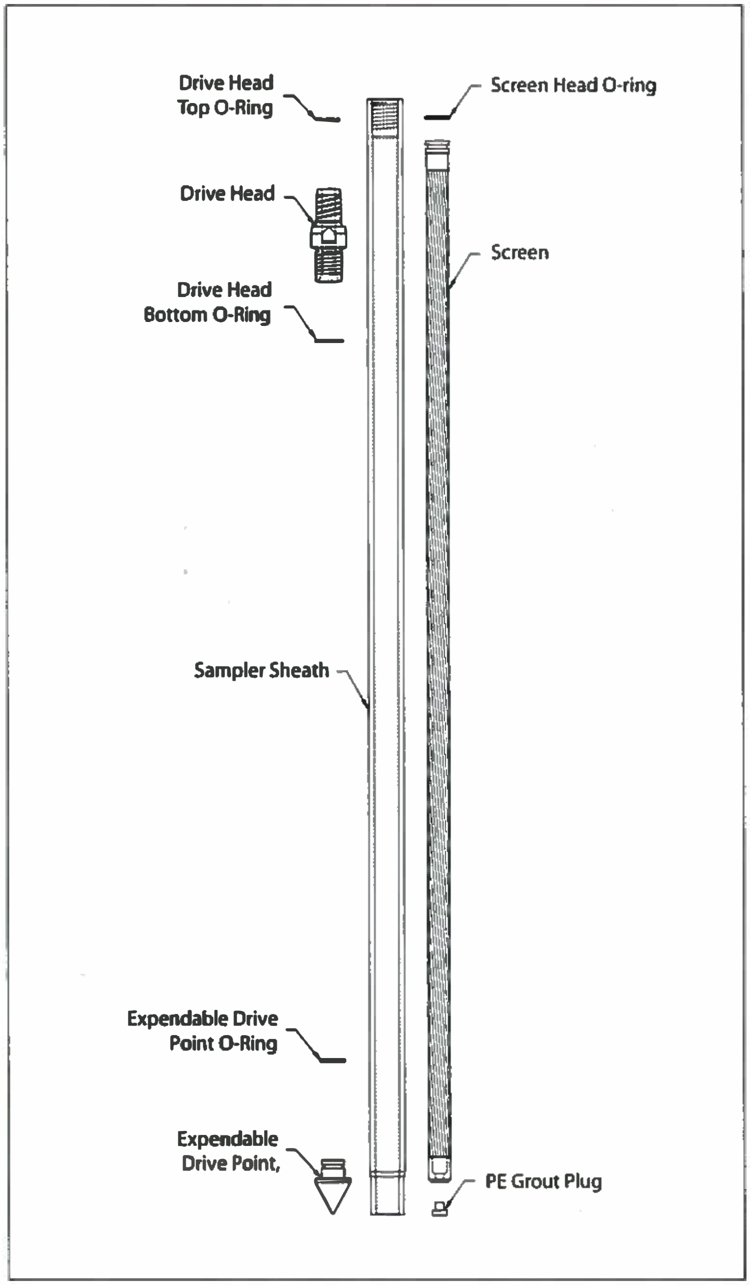
-Corporate Offices-
601 N. Broadway • Salina, KS 67401
1-800-436-7762 • Fax 785-825-2097
www.geoprobe.com

GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER

STANDARD OPERATING PROCEDURE

Technical Bulletin No. MK3142

PREPARED: November, 2006



GEOPROBE® SCREEN POINT 16 GROUNDWATER SAMPLER PARTS

Geoprobe Systems®

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Screen Point 16 Groundwater Sampler is manufactured under U.S. Patent 5,612,498

1.0 OBJECTIVE

The objective of this procedure is to drive a sealed stainless steel or PVC screen to depth, deploy the screen, obtain a representative water sample from the screen interval, and grout the probe hole during abandonment. The Screen Point 16 Groundwater Sampler enables the operator to conduct abandonment grouting that meets American Society for Testing and Materials (ASTM) Method D 5299 requirements for decommissioning wells and borings for environmental activities (ASTM 1993).

2.0 BACKGROUND

2.1 Definitions

Geoprobe®: A brand name of high quality, hydraulically powered machines that utilize both static force and percussion to advance sampling and logging tools into the subsurface. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling and monitoring, soil conductivity and contaminant logging, grouting, and materials injection.

Screen Point 16 (SP16) Groundwater Sampler: A direct push device consisting of a PVC or stainless steel screen that is driven to depth within a sealed, steel sheath and then deployed for the collection of representative groundwater samples. The assembled SP16 Sampler is approximately 51.5 inches (1308 mm) long with an OD of 1.625 inches (41 mm). Upon deployment, up to 41 inches (1041 mm) of screen can be exposed to the formation. The Screen Point 16 Groundwater Sampler is designed for use with 1.5-inch probe rods and machines equipped with the more powerful GH60 Hydraulic Hammer. Operators with GH40 Series hammers may chose to use this sampler in soils where driving is difficult.

Rod Grip Pull System: An attachment mounted on the hydraulic hammer of a direct push machine which makes it possible to retract the tool string with extension rods or flexible tubing protruding from the top of the probe rods. The Rod Grip Pull System includes a pull block with rod grip jaws that are bolted directly to the machine. A removable handle assembly straddles the tool string while hooking onto the pull block to effectively grip the probe rods as the hammer is raised. A separate handle assembly is required for each probe rod diameter.

2.2 Discussion

In this procedure, the assembled Screen Point 16 Groundwater Sampler (Fig. 2.1A) is threaded onto the leading end of a Geoprobe® probe rod and advanced into the subsurface with a Geoprobe® direct push machine. Additional probe rods are added incrementally and advanced until the desired sampling interval is reached. While the sampler is advanced to depth, O-ring seals at each rod joint, the drive head, and the expendable drive point provide a watertight system. This system eliminates the threat of formation fluids entering the screen before deployment and assures sample integrity.

Once at the desired sampling interval, extension rods are sent downhole until the leading rod contacts the bottom of the sampler screen. The tool string is then retracted approximately 44 inches (1118 mm) while the screen is held in place with the extension rods (Fig. 2.1B). As the tool string is retracted, the expendable point is released from the sampler sheath. The tool string and sheath may be retracted the full length of the screen or as little as a few inches if a small sampling interval is desired.

There are three types of screens that can be used in the Screen Point 16 Groundwater Sampler. Two of the these, a stainless steel screen with a standard slot size of 0.004 inches (0.10 mm) and a PVC screen with a standard slot size of 0.010 inches (0.25 mm), are recovered with the tool string after sampling. The third screen is also manufactured from PVC with a standard slot size of 0.010 inches (0.25 mm), but is designed to be left downhole when sampling is complete. This disposable screen has an exposed screen length of approximately 43 inches (1092 mm). The two screens that are recovered with the sampler both have an exposed screen length of approximately 41 inches (1041 mm).

(continued on following page)

An O-ring on the head of the stainless steel screens maintains a seal at the top of the screen. As a result, any liquid entering the sampler during screen deployment must first pass through the screen. PVC screens do not require an O-ring because the tolerance between the screen head and sampler sheath is near that of the screen slot size.

The screens are constructed such that flexible tubing, a mini-bailer, or a small-diameter bladder pump can be inserted into the screen cavity. This makes direct sampling possible from anywhere within the saturated zone. A removable plug in the lower end of the screens allows the user to grout as the sampler is extracted for further use.

Groundwater samples can be obtained in a number of ways. A common method utilizes polyethylene (TB25L) or Teflon® (TB25T) tubing and a Check Valve Assembly (GW4210). The check valve (with check ball) is attached to one end of the tubing and inserted down the casing until it is immersed in groundwater. Water is pumped through the tubing and to the ground surface by oscillating the tubing up and down.

An alternative means of collecting groundwater samples is to attach a peristaltic or vacuum pump to the tubing. This method is limited in that water can be pumped to the surface from a maximum depth of approximately 26 feet (8 m). Another technique for groundwater sampling is to use a stainless steel Mini-Bailer Assembly (GW41). The mini-bailer is lowered down the inside of the casing below the water level where it fills with water and is then retrieved from the casing.

The latest option for collecting groundwater from the SP16 sampler is to utilize a Geoprobe® MB470 Series Mechanical Bladder Pump (MBP)*. The MBP may be used to meet requirements of the low-flow sampling protocol (Puls and Barcelona 1996, ASTM 2003). Through participation in a U.S. EPA Environmental Technology Verification study, it was confirmed that the MB470 can provide representative samples (EPA 2003).

**The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

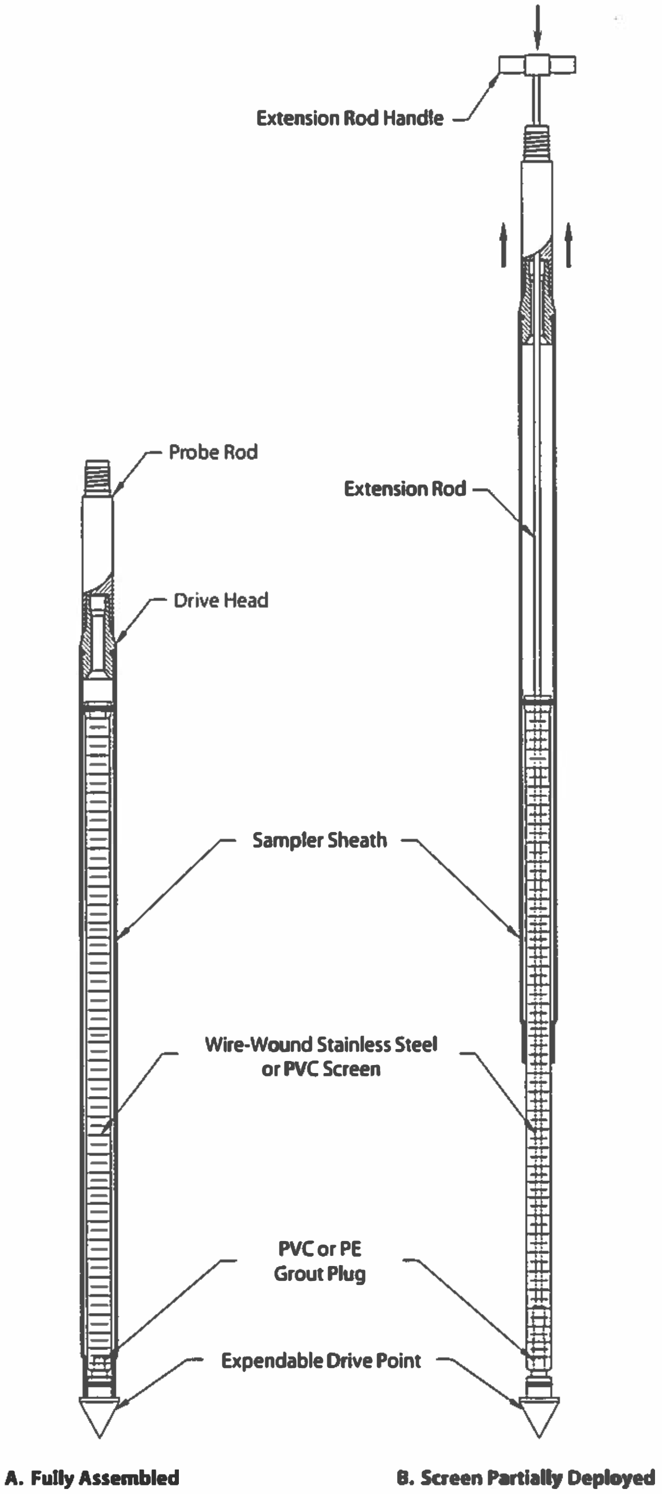


FIGURE 2.1
Screen Point 16 Groundwater Sampler

3.0 TOOLS AND EQUIPMENT

The following tools and equipment can be used to successfully recover representative groundwater samples with the Geoprobe® Screen Point 16 Groundwater Sampler. Refer to Figures 3.1 and 3.2 for identification of the specified parts. Tools are listed below for the most common SP16 / 1.5-inch probe rod configurations. Additional parts for optional rod sizes and accessories are listed in Appendix A.

SP16 Sampler Parts	**Part Number**
SP16 Sampler Sheath	15187
SP16 Drive Head, 0.5-inch bore, 1.5-inch rods*	18307
SP16 O-ring Service Kit, 1.5-inch rods *(includes 4 each of the O-ring packets below)*	15844
O-rings for Top of SP16 Drive Head, 1.5-inch rods only (Pkt. of 25)	*15389*
O-rings for Bottom of SP16 Drive Head (Pkt. of 25)	*13196*
O-rings for GW1520 Screen Head (Pkt. of 25)	*GW1520R*
O-rings for SP16 Expendable Drive Point (Pkt. of 25)	*GW1555R*
Screen, Wire-Wound Stainless Steel, 4-Slot*	GW1520
Grout Plugs, PE (Pkg. of 25)	GW1552K
Expendable Drive Points, steel, 1.625-inch OD (Pkg. of 25)*	GW1555K
Screen Point 16 Groundwater Sampler Kit, 1.5-inch Probe Rods *(includes 1 each of: 15187, 18307, 15844, GW1520, GW1535, GW1540, GW1555K, and GW1552K)*	15770

Probe Rods and Probe Rod Accessories	**Part Number**
Drive Cap, 1.5-inch probe rods, threadless, (for GH60 Hammer)	12787
Pull Cap, 1.5-inch probe rods	15090
Probe Rod, 1.5-inch x 60-inch*	11121

Extension Rods and Extension Rod Accessories	**Part Number**
Screen Push Adapter	GW1535
Grout Plug Push Adapter	GW1540
Extension Rod, 60-inch*	10073
Extension Rod Coupler	AT68
Extension Rod Handle	AT69
Extension Rod Jig	AT690
Extension Rod Quick Link Coupler, pin	AT695
Extension Rod Quick Link Coupler, box	AT696

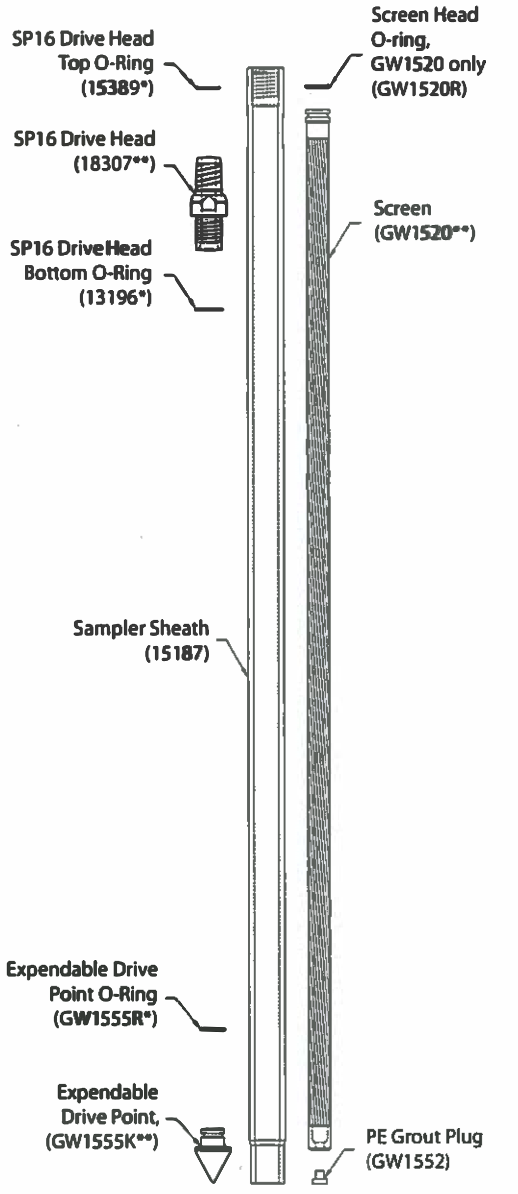
Grout Accessories	**Part Number**
Grout Nozzle, for 0.375-inch OD tubing	GW1545
High-Pressure Nylon Tubing, 0.375-inch OD / 0.25-inch ID, 100-ft. (30 m)	11633
Grout Machine, self-contained*	GS1000
Grout System Accessories Package, 1.5-inch rods	GS1015

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.375-inch OD, 500 ft.*	TB25L
Check Valve Assembly, 0.375-inch OD Tubing*	GW4210
Water Level Meter, 0.438-inch OD Probe, 100 ft. cable*	GW2000
Mechanical Bladder Pump**	MB470
Mini Bailer Assembly, stainless steel	GW41

Additional Tools	**Part Number**
Adjustable Wrench, 6.0-inch	FA200
Adjustable Wrench, 10.0-inch	FA201
Pipe Wrenches	NA

* See Appendix A for additional tooling options.

** Refer to the Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.



* Included in the SP16 O-ring Service Kit (15844)
** Part numbers show most common tool configuration. See Appendix A for alternative parts.

FIGURE 3.1
SP16 Sampler Parts

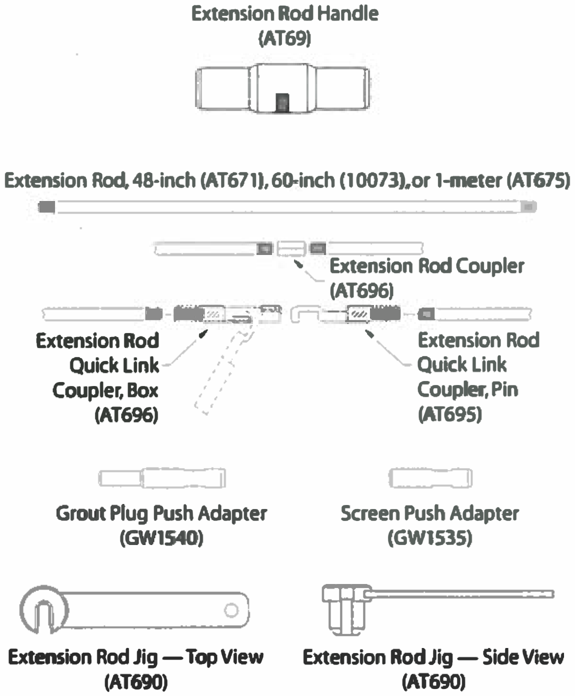


FIGURE 3.2
Geoprobe® Extension Rods and Accessories

4.0 OPERATION

4.1 Basic Operation

The SP16 sampler utilize a stainless steel or PVC screen which is encased in an alloy steel sampler sheath. An expendable drive point is placed in the lower end of the sheath while a drive head is attached to the top. O-rings on the drive head and expendable point provide a watertight sheath which keeps contaminants out of the system as the sampler is driven to depth.

Once the sampling interval is reached, extension rods equipped with a screen push adapter are inserted down the ID of the probe rods. The tool string is then retracted up to 44 inches (1118 mm) while the screen is held in place with the extension rods. The system is now ready for groundwater sampling. When sampling is complete, a removable plug in the bottom of the screen allows for grouting below the sampler as the tool string is retrieved.

4.2 Sampler Options

The Screen Point 15 and Screen Point 16 Groundwater Samplers are nearly identical. Subtle differences in the design of the SP16 sampler make it more durable than the earlier SP15 system. Operators of GH60-equipped machines should always utilize SP16 tooling. Operators of machines equipped with GH40 Series hammers may also choose SP16 tooling when sampling in difficult probing conditions.

A 1.75-inch OD Expendable Drive Point (17066K) and Disposable PVC Screen (16089) provide two useful options for the SP16 sampler. The 1.75-inch drive point may be used when soil conditions make it difficult to remove the sampler after driving to depth. The disposable PVC screen may be left downhole after sampling (when regulations permit) to eliminate the time required for screen decontamination.

4.3 Decontamination

In order to collect representative groundwater samples, all sampler parts must be thoroughly cleaned before and after each use. Scrub all metal parts using a stiff brush and a nonphosphate soap solution. Steam cleaning may be substituted for hand-washing if available. Rinse with distilled water and allow to air-dry before assembly.

4.4 SP16 Sampler Assembly (Figure 4.1)

Part numbers are listed for a standard SP16 sampler using 1.5-inch probe rods. Refer to Page 6 for screen and drive head alternatives.

1. Place an O-ring on a steel expendable drive point (GW1555K). Firmly seat the expendable point in the necked end of a sampler sheath (15187).

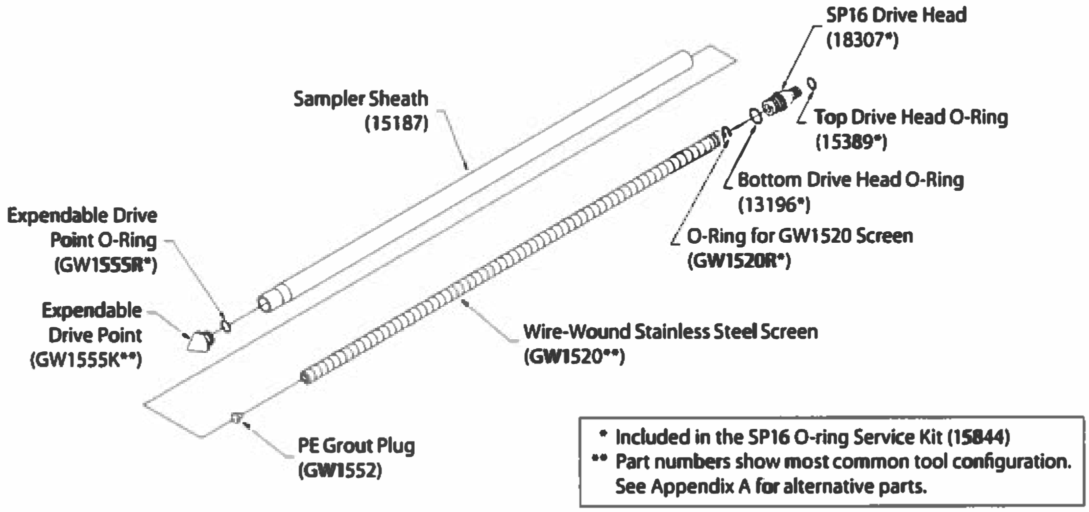
2. Install a PE Grout Plug (GW1552) in the bottom end of a Wire-wound Stainless Steel Screen (GW1520). Place a GW1520R O-ring in the groove on the top end of the screen.

3. Slide the screen inside of the sampler sheath with the grout plug toward the bottom of the sampler. Ensure that the expendable point was not displaced by the screen.

4. Install a bottom O-ring (13196) on a Drive Head (18307 or 15188). Thread the drive head into the sampler sheath using an adjustable wrench if necessary to ensure complete engagement of the threads. Attach a Drive Cap (12787 or 15590) to the top of the drive head.

   NOTE: The 18307 drive head should be used whenever possible as the smaller 0.5-inch ID provides a greater material cross-section for increased durability.

Sampler assembly is complete.



* Included in the SP16 O-ring Service Kit (15844)
** Part numbers show most common tool configuration. See Appendix A for alternative parts.

FIGURE 4.1
Screen Point 16 Groundwater Sampler Assembly

4.5 Advancing the SP16 Sampler

To provide adequate room for screen deployment with the Rod Grip Pull System, the probe derrick should be extended a little over halfway out of the carrier vehicle when positioning for operation.

1. Begin by placing the assembled sampler (Fig. 2.1.A) in the driving position beneath the hydraulic hammer of the direct push machine as shown in Figure 4.2.

2. Advance the sampler with the throttle control at slow speed for the first few feet to ensure that the sampler is aligned properly. Switch to fast speed for the remainder of the probe stroke.

3. Completely raise the hammer assembly. Remove the drive cap and place an O-ring in the top groove of the drive head. Distilled water may be used to lubricate the O-ring if needed.

   Add a probe rod (length to be determined by operator) and reattach the drive cap to the rod string. Drive the sampler the entire length of the new rod with the throttle control at fast speed.

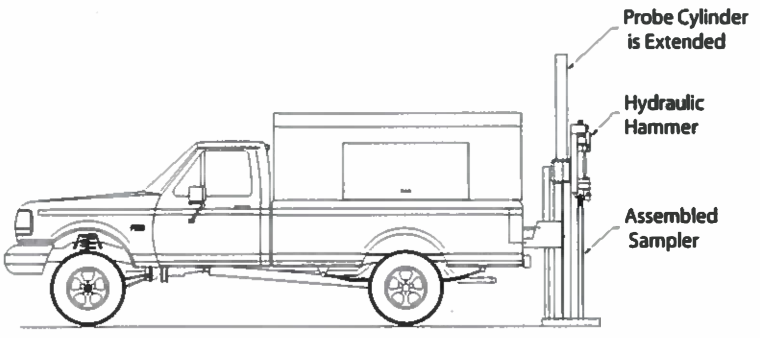


FIGURE 4.2
Screen Point 16 Groundwater Sampler in Driving Position

4. Repeat Step 3 until the desired sampling interval is reached. Approximately 12 inches (305 mm) of the last probe rod must extend above the ground surface to allow attachment of the puller assembly. A 12-inch (305 mm) rod may be added if the tool string is over-driven.

5. Remove the drive cap and retract the probe derrick away from the tool string.

4.6 Screen Deployment

1. Thread a screen push adapter (GW1535) on an extension rod of suitable length (AT671, 10073, or AT675). Attach a threaded coupler (AT68) to the other end of the extension rod. Lower the extension rod inside of the probe rod taking care not to drop it down the tool string. An extension rod jig (AT690) may be used to hold the rods.

2. Add extension rods until the adapter contacts the bottom of the screen. To speed up this step, it is recommended that Extension Rod Quick Links (AT695 and AT696) are used at every other rod joint.

3. Ensure that at least 48 inches (1219 mm) of extension rod protrudes from the probe rod. Thread an extension rod handle (AT69) on the top extension rod.

4. Maneuver the probe assembly into position for pulling.

5. Raise (pull) the tool string while physically holding the screen in place with the extension rods (Fig. 4.3.B). A slight knock with the extension rod string will help to dislodge the expendable point and start the screen moving inside the sheath.

   Raise the hammer and tool string about 44 inches (1118 cm) if using a GW1520 or GW1530 screen. At this point the screen head will contact the necked portion of the sampler sheath (Fig. 4.3.C.) and the extension rods will rise with the probe rods. Use care when deploying a PVC screen so as not to break the screen when it contacts the bottom of the sampler sheath.

   The Disposable Screen (16089) will extend completely out of the sheath if the tool string is raised more than 45 inches (1143 mm). Measure and mark this distance on the top extension rod to avoid losing the screen during deployment.

6. Remove the rod grip handle, lower the hammer assembly, and retract the probe derrick. Remove the top extension rod (with handle) and top probe rod. Finally, extract all extension rods.

7. Groundwater samples can now be collected with a mini-bailer, peristaltic or vacuum pump, tubing bottom check valve assembly, bladder pump, or other acceptable small diameter sampling device.

   When inserting tubing or a bladder pump down the rod string, ensure that it enters the screen interval. The leading end of the tubing or bladder pump will sometimes catch at the screen head giving the illusion that the bottom of the screen has been reached. An up-and-down motion combined with rotation helps move the tubing or bladder pump past the lip and into the screen.

4.7 Abandonment Grouting for GW1520 and GW1530 Screens

The SP16 Sampler can meet ASTM D 5299 requirements for abandoning environmental wells or borings when grouting is conducted properly. A removable grout plug makes it possible to deploy tubing through the bottom of GW1520 and GW1530 screens. A GS500 or GS1000 Grout Machine is then used to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling. Attach the rod grip puller to the top probe rod. Raise the tool string approximately 4 to 6 inches (102 to 152 cm) to allow removal of the grout plug.

2. Thread the Grout Plug Push Adapter (GW1540) onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the grout plug at the bottom of the screen. Attach the handle to the top extension rod. When the extension rods are slightly raised and lowered, a relatively soft rebound should be felt as the adapter contacts the grout plug. This is especially true when using a PVC screen.

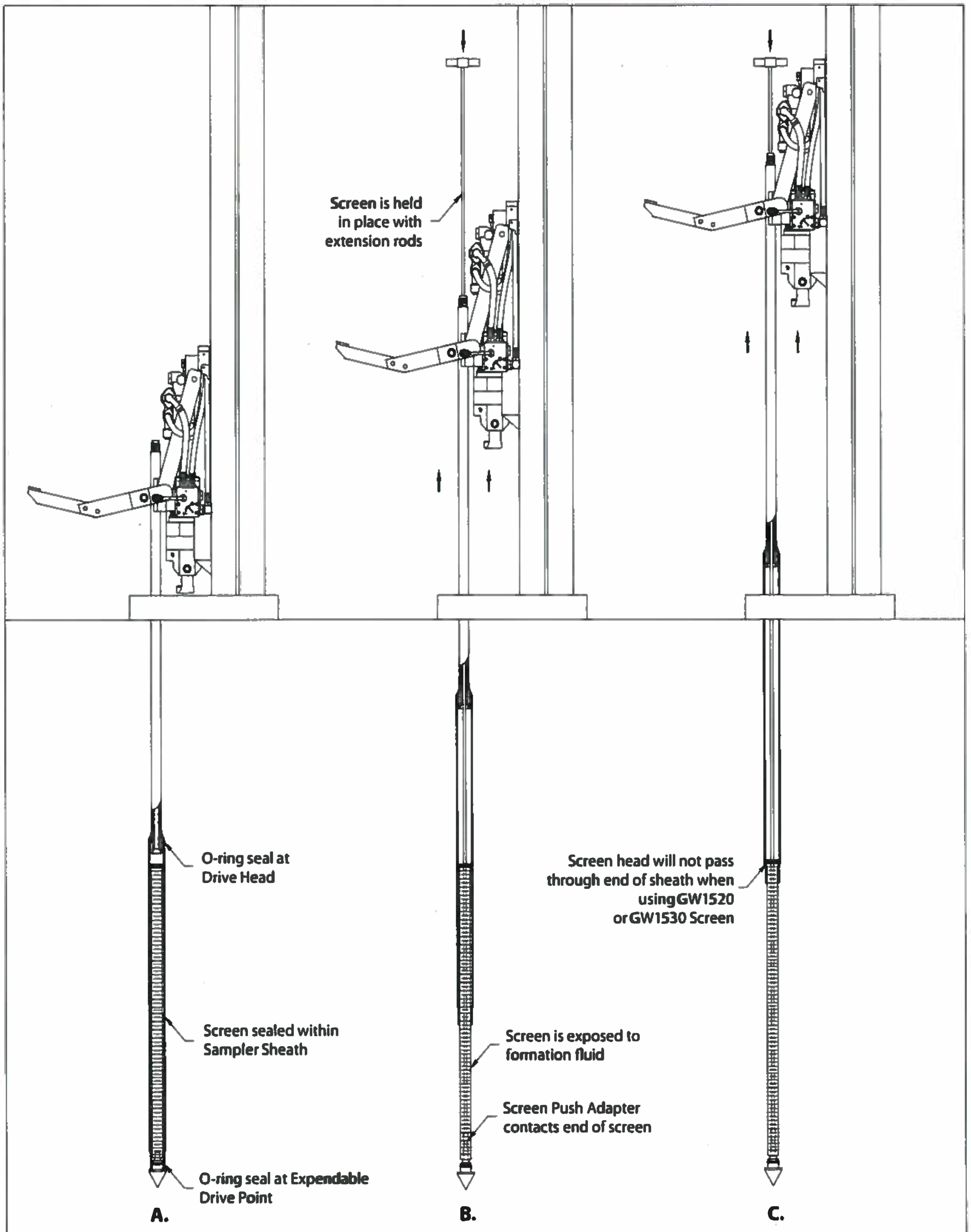
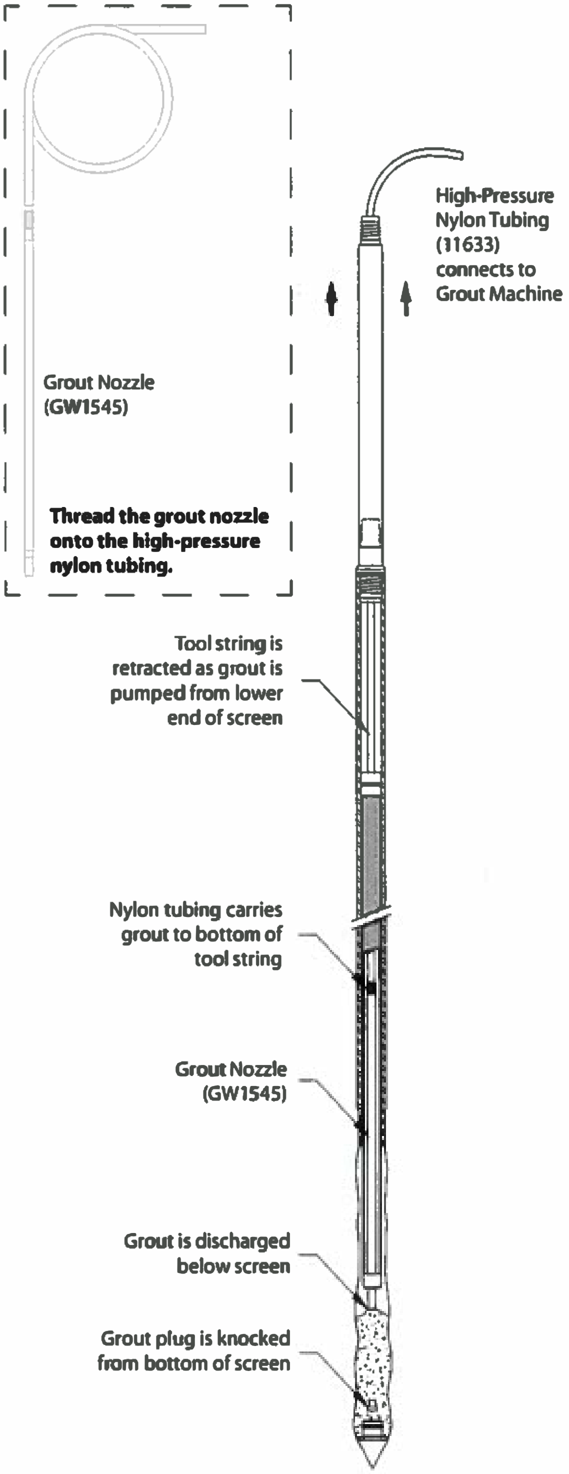


FIGURE 4.3
Screen Deployment for SP16 Sampler



Thread the grout nozzle onto the high-pressure nylon tubing.

FIGURE 4.4
Grouting the SP16 Sampler With a GW1520 or GW1530 Screen

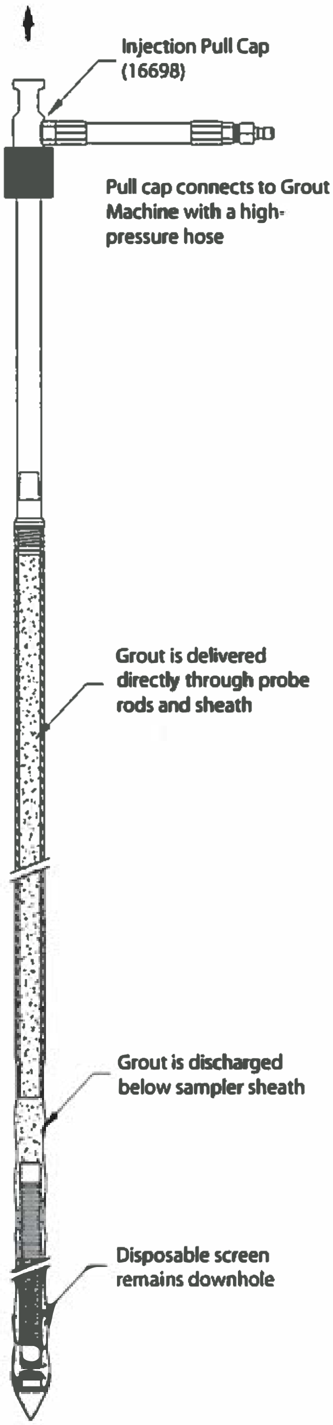


FIGURE 4.5
Grouting the SP16 Sampler With a 16089 Disposable Screen

3. Place a mark on the extension rod even with the top of the probe rod. Apply downward pressure on the extension rods and push the grout plug out of the screen. The mark placed on the extension rod should now be below the top of the probe rod. Remove all extension rods.

   Note: When working with a stainless steel screen, it may be necessary to raise and quickly lower the extension rods to jar the grout plug free. When the plug is successfully removed, a metal-on-metal sensation may be noted as the extension rods are gently "bounced" within the probe rods.

4. A Grout Nozzle (GW1545) is now connected to High-Pressure Nylon Tubing (11633) and inserted down through the probe rods to the bottom of the screen (Fig. 4.4). It may be necessary to pump a small amount of clean water through the tubing during deployment to jet out sediments that settled in the bottom of the screen. Resistance will sometimes be felt as the grout nozzle passes through the drive head. Rotate the tubing while moving it up-and-down to ensure that the nozzle has reached the bottom of the screen and is not hung up on the drive head.

   ***Note:** All probe rods remain strung on the tubing as the tool string is pulled. Provide extra tubing length to allow sufficient room to lay the rods on the ground as they are removed. An additional 20 feet is generally enough.*

5. Operate the grout pump while pulling the first rod with the rod grip pull system. Coordinate pumping and pulling rates so that grout fills the void left by the sampler. After pulling the first rod, release the rod grip handle, fully lower the hammer, and regrip the tool string. Unthread the top probe and slide it over the tubing placing it on the ground near the end of the tubing.

6. Repeat Step 5 until the sampler is retrieved. Do not bend or kink the tubing when pulling and laying out the probe rods. Sharp bends create weak spots in the tubing which may burst when pumping grout. Remember to operate the grout pump only when pulling the rod string. The probe hole is thus filled with grout from the bottom up as the rods are extracted.

7. Promptly clean all probe rods and sampler parts before the grout sets up and clogs the equipment.

4.8 Abandonment Grouting for the 16089 Disposable Screen

ASTM D 5299 requirements can also be met for the SP16 samplers when using the 16089 disposable screen. Because the screen remains downhole after sampling, the operator may choose either to deliver grout to the bottom of the tool string with nylon tubing or pump grout directly through the probe rods using an Injection Pull Cap (16698). A GS500 or GS1000 Grout Machine is needed to pump grout into the open probe hole as the sampler is withdrawn. The following procedure is presented as an example only and should be modified to satisfy local abandonment grouting regulations.

1. Maneuver the probe assembly into position for pulling with the rod grip puller.

2. Thread the screen push adapter onto an extension rod. Insert the adapter and extension rod inside the probe rod string. Add extension rods until the adapter contacts the bottom of the screen. Attach the handle to the top extension rod.

3. The disposable screen must be extended at least 46 inches (1168 mm) to clear the bottom of the sampler sheath. Considering the length of screen deployed in Section 4.7, determine the remaining distance required to fully extend the screen from the sheath. Mark this distance on the top extension rod.

4. Pull the tool string up to the mark on the top extension rod while holding the disposable screen in place.

   The screen is now fully deployed and the sampler is ready for abandonment grouting. Apply grout to the bottom of the tool string during retrieval using either flexible tubing (as described in Section 4.7) or an injection pull cap (Fig. 4.5). This section continues with a description of grouting with a pull cap.

5. Remove the rod grip handle and maneuver the probe assembly directly over the tool string. Thread an Injection Pull Cap (16698) onto the top probe rod and close the hammer pull latch over the top of the pull cap.

6. Connect the pull cap to a Geoprobe® grout machine using a high-pressure grout hose.

7. Operate the pump to fill the entire tool string with grout. When a sufficient volume has been pumped to fill the tool string, begin pulling the rods and sampler while continuing to operate the grout pump. Considering the known pump volume and sampler cross-section, time tooling withdrawal to slightly "overpump" grout into the subsurface. This will ensure that all voids are filled during sampler retrieval.

   The grouting process can lubricate the probe hole sufficiently to cause the tool string to slide back downhole when disconnected from the pull cap. Prevent this by withdrawing the tool string with the rod grip puller while maintaining a connection to the grout machine with the pull cap.

4.9 Retrieving the Screen Point 16 Sampler

If grouting is not required, the Screen Point 16 Sampler can be retrieved by pulling the probe rods as with most other Geoprobe® applications. The Rod Grip Pull System should be used for this process as it allows the operator to remove rods without completely releasing the tool string. This avoids having the probe rods fall back downhole when released during the pulling procedure. A standard Pull Cap (15164) may still be used if preferred. Refer to the Owner's Manual for your Geoprobe® direct push machine for specific instructions on pulling the tool string.

5.0 REFERENCES

American Society of Testing and Materials (ASTM), 2003. D6771-02 Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations. ASTM, West Conshocken, PA. (www.astm.org)

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Puls, Robert W., and Michael J. Barcelona, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground Water Sampling Procedures. EPA/540/S-95/504. April.

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Appendix A
ALTERNATIVE PARTS

The following parts are available to meet unique soil conditions. See section 3.0 for a complete listing of the common tool configurations for the Geoprobe® Screen Point 16 Groundwater Sampler.

SP16 Sampler Parts and Accessories	**Part Number**
SP16 Drive Head, 0.625-inch bore, 1.5-inch rods	15188
Expendable Drive Points, aluminum, 1.625-inch OD (Pkg. of 25)	GW1555ALK
Expendable Drive Points, steel, 1.75-inch OD (Pkg. of 25)	17066K
Screen, PVC, 10-Slot	GW1530
Screen, Disposable, PVC, 10-Slot	16089

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.25-inch OD, 500 ft	TB17L
Polyethylene Tubing, 0.5-inch OD, 500 ft	TB37L
Polyethylene Tubing, 0.625-inch OD, 50 ft	TB50L
Check Valve Assembly, 0.25-inch OD Tubing	GW4240
Check Valve Assembly, 0.5-inch OD Tubing	GW4220
Check Valve Assembly, 0.625-inch OD Tubing	GW4230
Water Level Meter, 0.375-inch OD Probe, 100-ft. cable	GW2001
Water Level Meter, 0.438-inch OD Probe, 200-ft. cable	GW2002
Water Level Meter, 0.375-inch OD Probe, 200-ft. cable	GW2003
Water Level Meter, 0.438-inch OD Probe, 30-m cable	GW2005
Water Level Meter, 0.438-inch OD Probe, 60-m cable	GW2007
Water Level Meter, 0.375-inch OD Probe, 60-m cable	GE2008

Grouting Accessories	**Part Number**
Grout Machine, auxiliary-powered	GS500

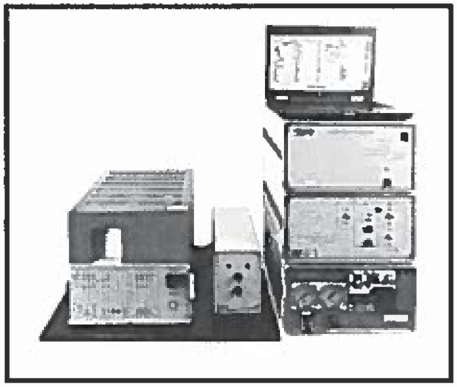
Probe Rods, Extension Rods, and Accessories	**Part Number**
Probe Rod, 1.5-inch x 1-meter	17899
Probe Rod, 1.5-inch x 48-inch	13359
Drive Cap, 1.5-inch rods (for GH40 Series Hammer)	15590
Rod Grip Pull Handle, 1.5-inch Probe Rods (for GH40 Series Hammer)	GH1555
Extension Rod, 48-inch	AT671
Extension Rod, 1-meter	AT675

Geoprobe Systems®

A DIVISION OF KEJR, INC.

Corporate Headquarters
601 N. Broadway • Salina, Kansas 67401
1-800-GEOPROBE (1-800-436-7762) • Fax (785) 825-2097
www.geoprobe.com

LL MIP Setup & Operation



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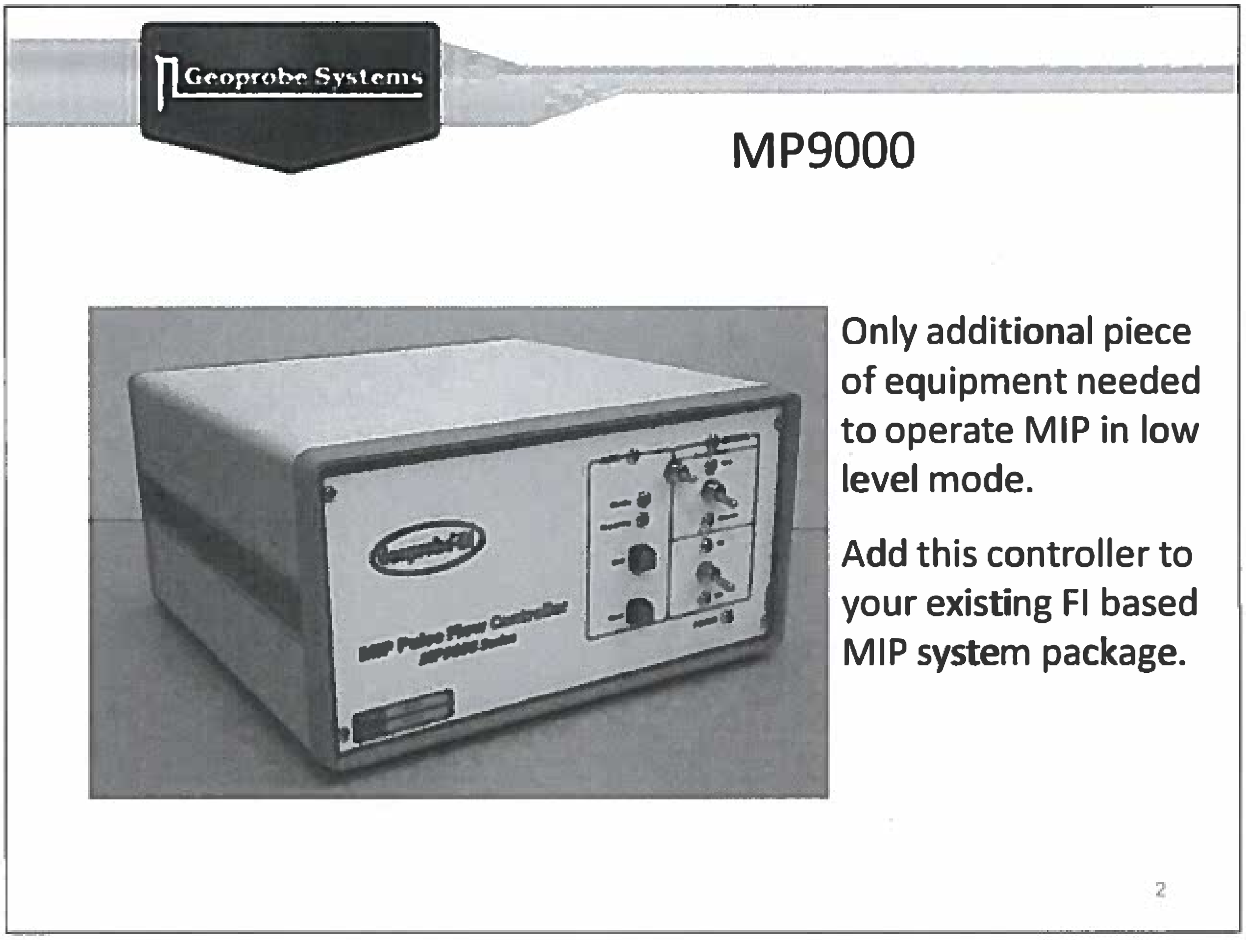
Dan Pipp
May 2014



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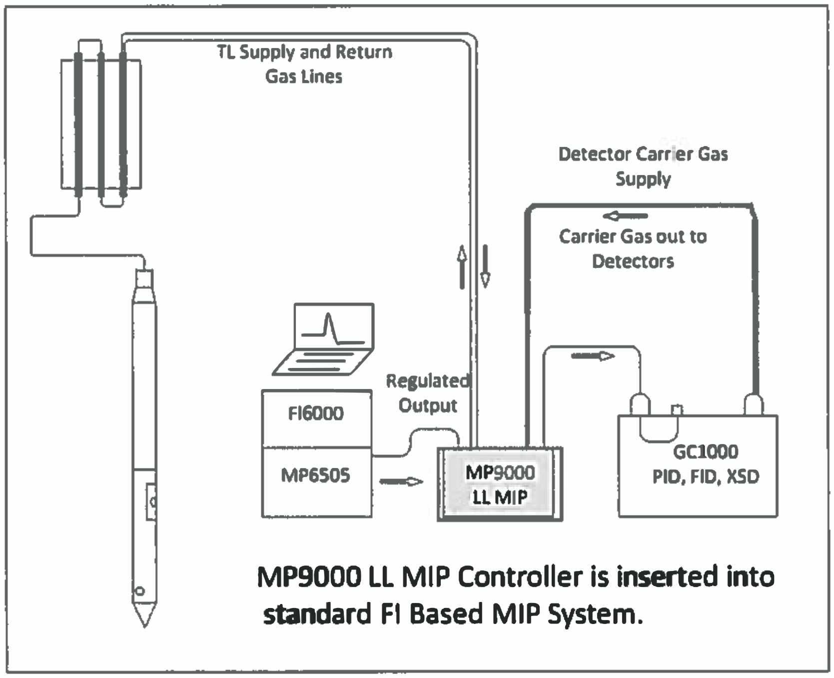
MP9000

Only additional piece of equipment needed to operate MIP in low level mode.

Add this controller to your existing FI based MIP system package.

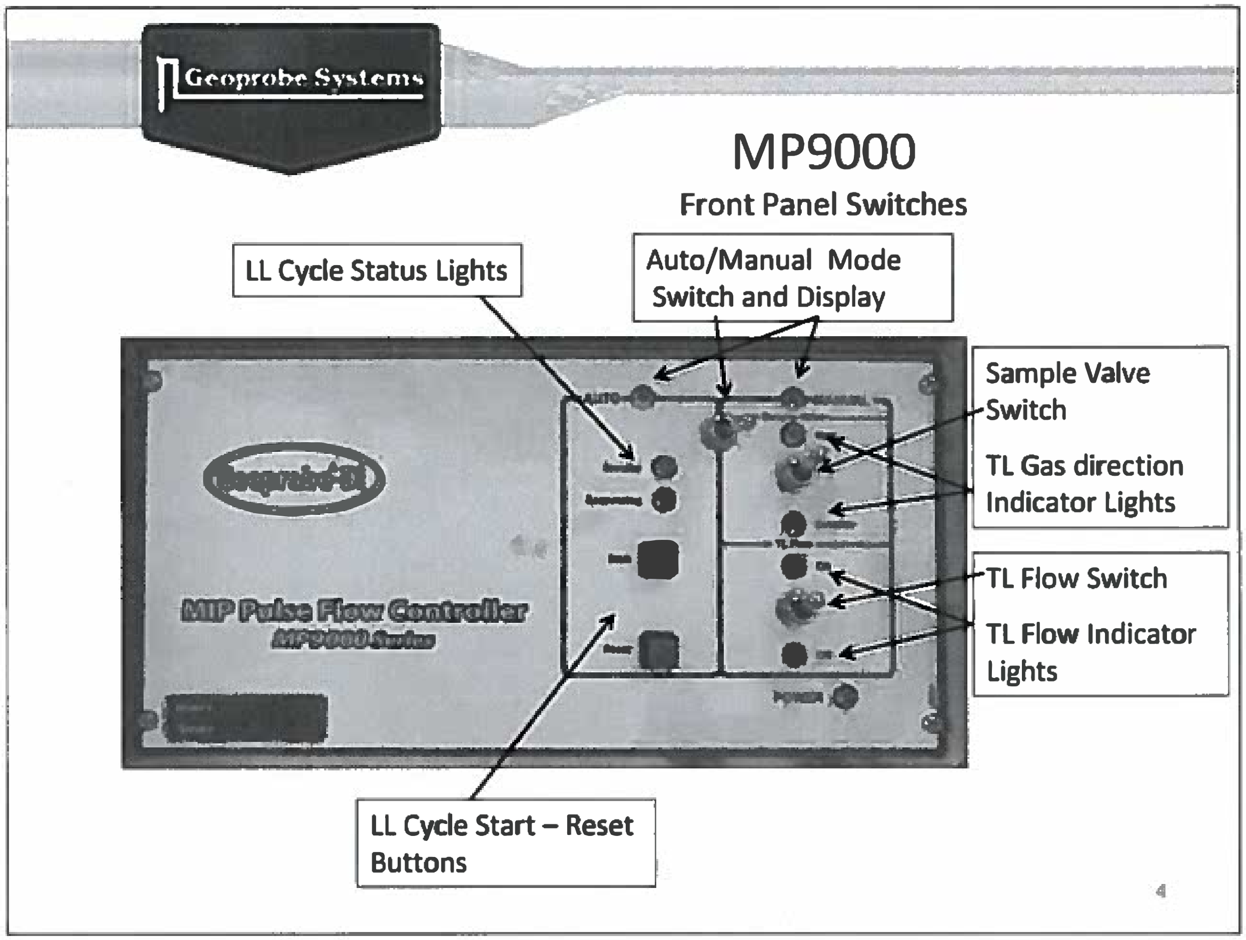
The low level MIP controller (MP9000) handles all of the low level cycling of the trunkline flow and the valve switching which directs either clean carrier gas or the trunkline carrier gas to the detectors. This is all handled automatically by the DI acquisition low level software addition.

MP9000



MP9000 LL MIP Controller is inserted into standard FI Based MIP System.

When the low level MIP controller is added to the current FI based MIP system, the gas lines of the different systems are all plumbed through this controller.



MP9000

Front Panel Switches

LL Cycle Status Lights

Auto/Manual Mode Switch and Display

Sample Valve Switch

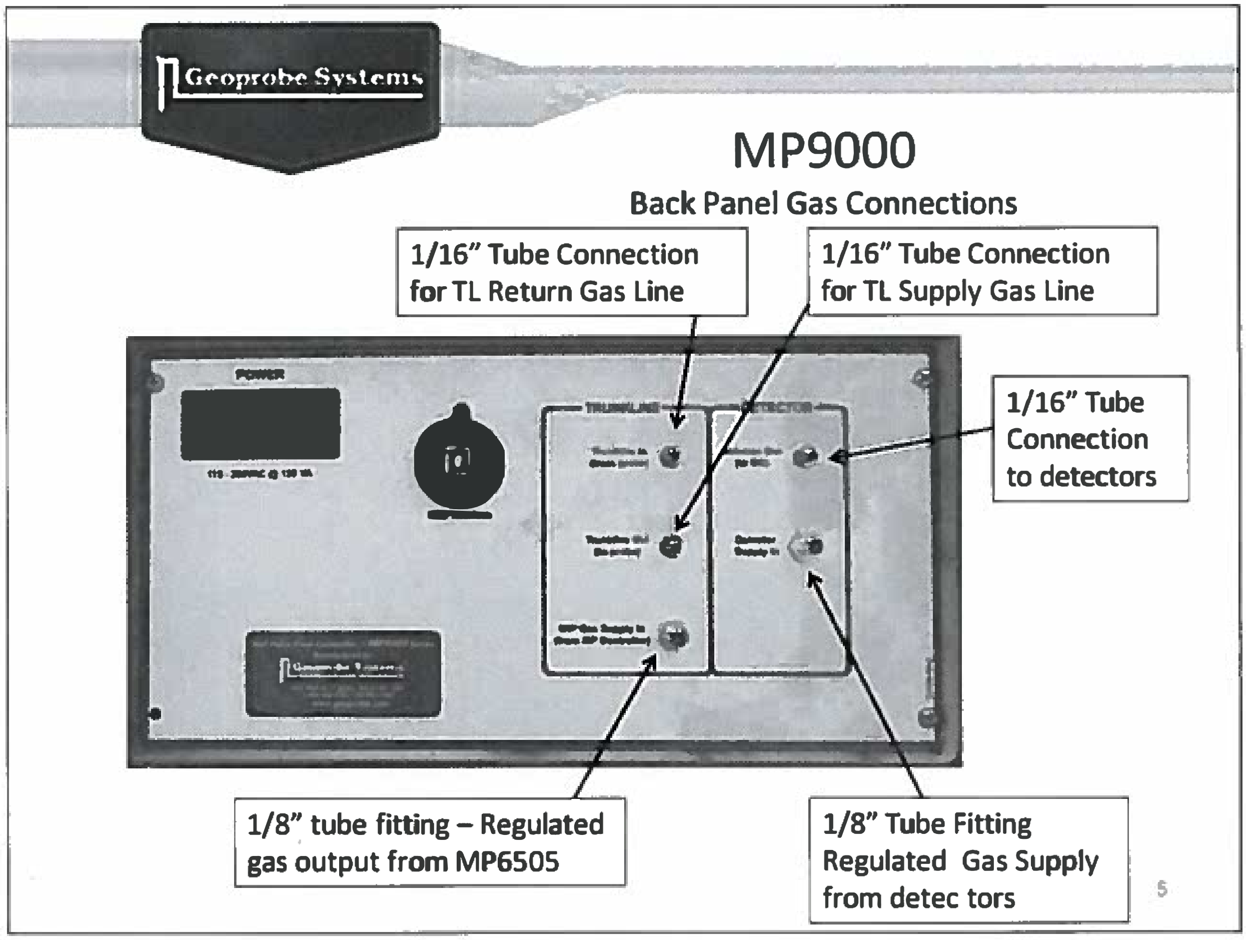
TL Gas direction Indicator Lights

TL Flow Switch

TL Flow Indicator Lights

LL Cycle Start – Reset Buttons

The low level MIP controller (MP9000) handles all of the low level cycling of the trunkline flow and the valve switching which directs either clean carrier gas or the trunkline carrier gas to the detectors. This is all handled automatically by the DI acquisition low level software addition.



Geoprobe Systems

MP9000

Back Panel Gas Connections

1/16” Tube Connection for TL Return Gas Line

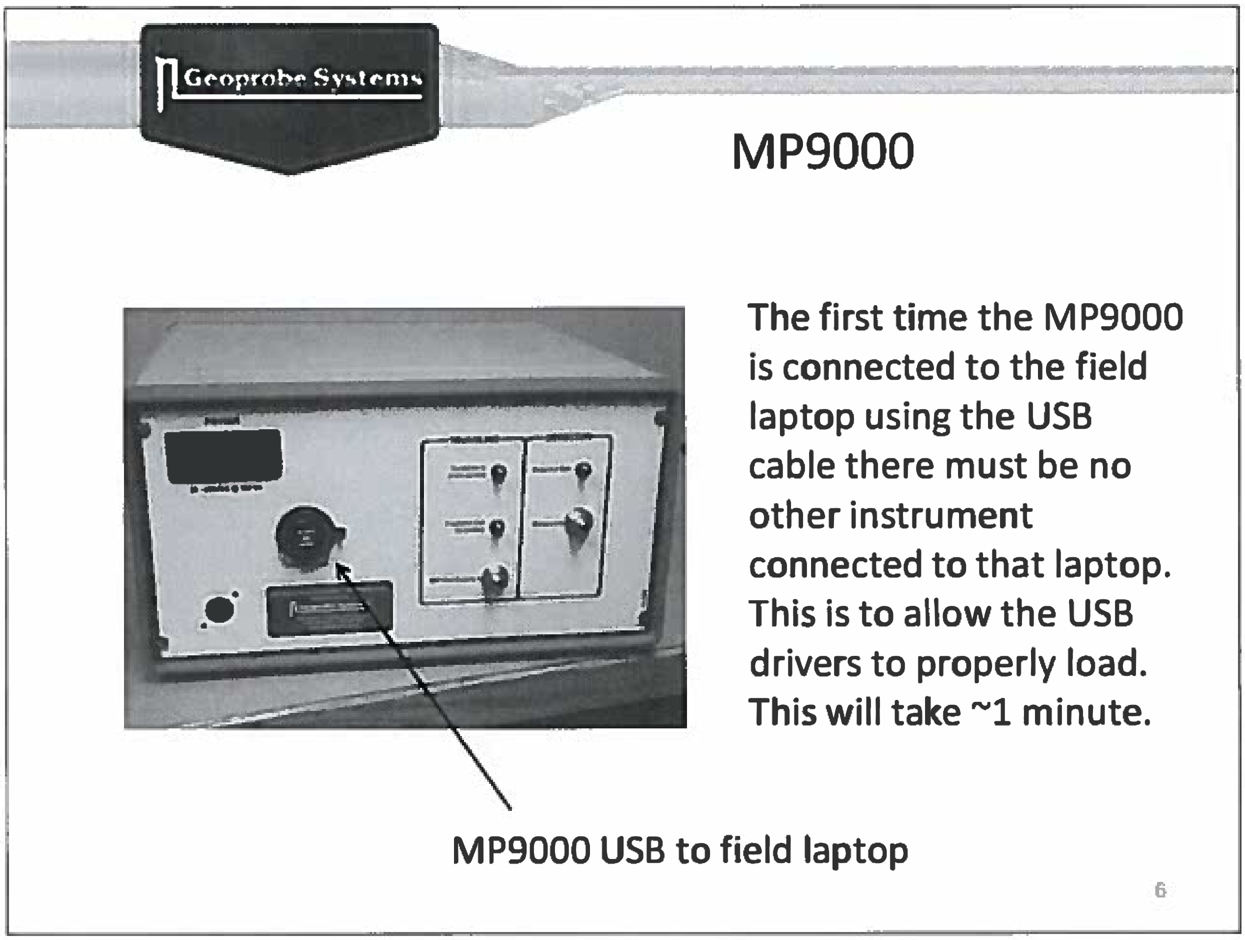
1/16” Tube Connection for TL Supply Gas Line

1/16” Tube Connection to detectors

1/8” tube fitting – Regulated gas output from MP6505

1/8” Tube Fitting Regulated Gas Supply from detec tors

In the trunkline section of the MP9000 rear panel, an 1/8” line from the regulated output of the MP6505 MIP controller connects to the trunkline supply gas. Connect both of the 1/16” trunkline gas lines – supply and return above the trunkline supply input. In the detector section an 1/8” detector gas supply line is connected. This supply gas needs to be created from an independent controller typically at the gas chromatograph. Above the detector gas supply is a 1/16” fitting for the transfer line which takes the contaminants over to the detectors.



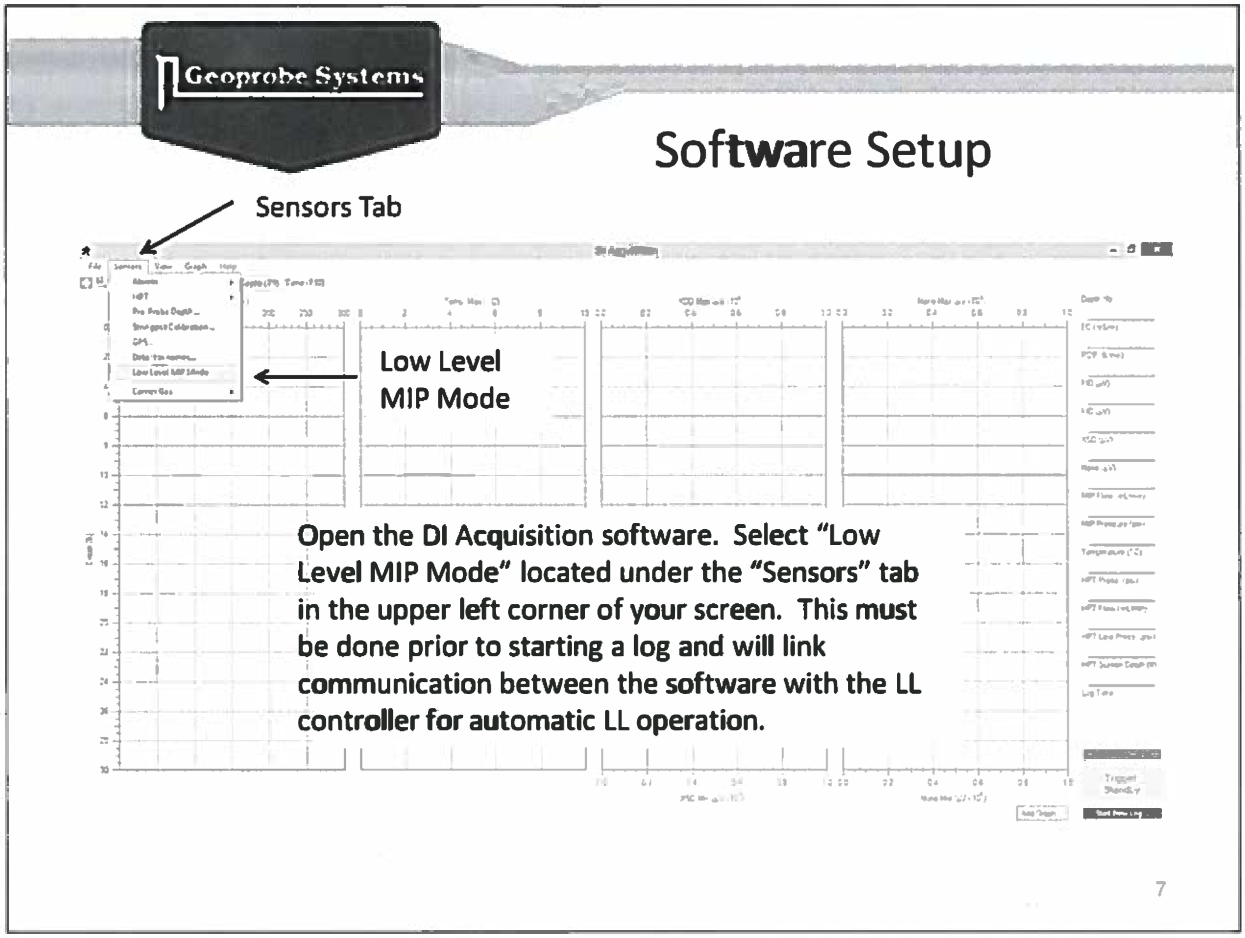
Geoprobe Systems

MP9000

The first time the MP9000 is connected to the field laptop using the USB cable there must be no other instrument connected to that laptop. This is to allow the USB drivers to properly load. This will take ~1 minute.

MP9000 USB to field laptop

It is very important for proper USB driver installation that the FI6000 is not connected to the field computer the first time the MP9000 LL controller is connected to the field laptop. If the FI6000 USB cable is connected at the same time the MP9000 is connected to any laptop for the first time the MP9000 the USB driver installation process will get blocked. When this occurs the software cannot recognize that the MP9000 is present and the software communication cannot happen resulting in an error message when the "Low Level MIP Mode" is selected in the next step. That error message will read: "No low level MIP box could be found." This is the same error that occurs if the USB cable is not connected to the laptop. Once again to ensure proper USB driver installation the first time the MP9000 is connected to each new field laptop only have the MP9000 USB connected no other instruments.



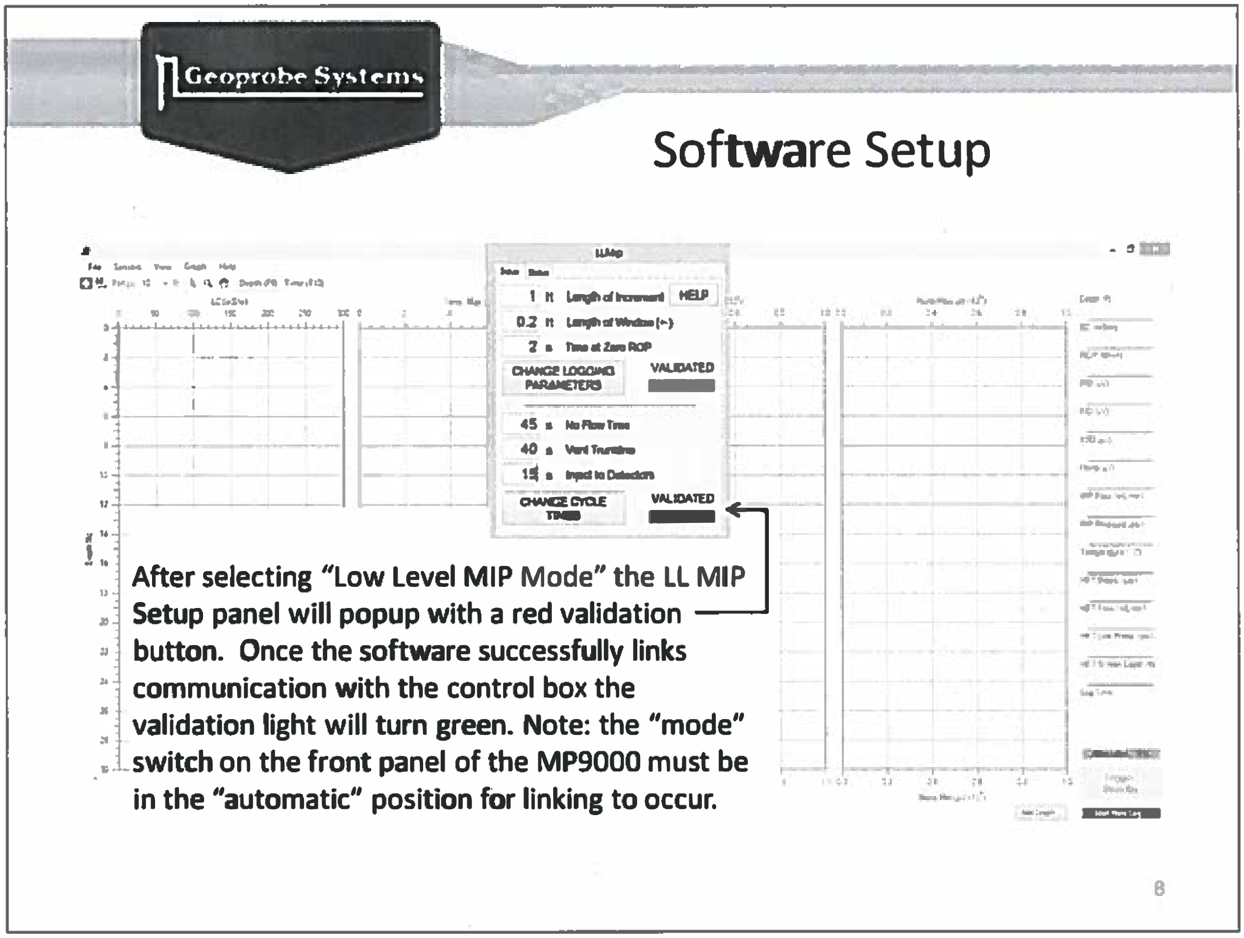
Software Setup

Sensors Tab

Low Level MIP Mode

Open the DI Acquisition software. Select "Low Level MIP Mode" located under the "Sensors" tab in the upper left corner of your screen. This must be done prior to starting a log and will link communication between the software with the LL controller for automatic LL operation.

Download and install the most current version of the DI Acquisition software from the Geoprobe® website: http://geoprobe.com/direct-image-software-downloads. After starting the DI Acquisition software the first selection that needs to be made is to select the "Sensors" tab and them "Low Level MIP Mode". For the software to link up to the MP9000 the controller power needs to be on and connected to the laptop via the USB cable.

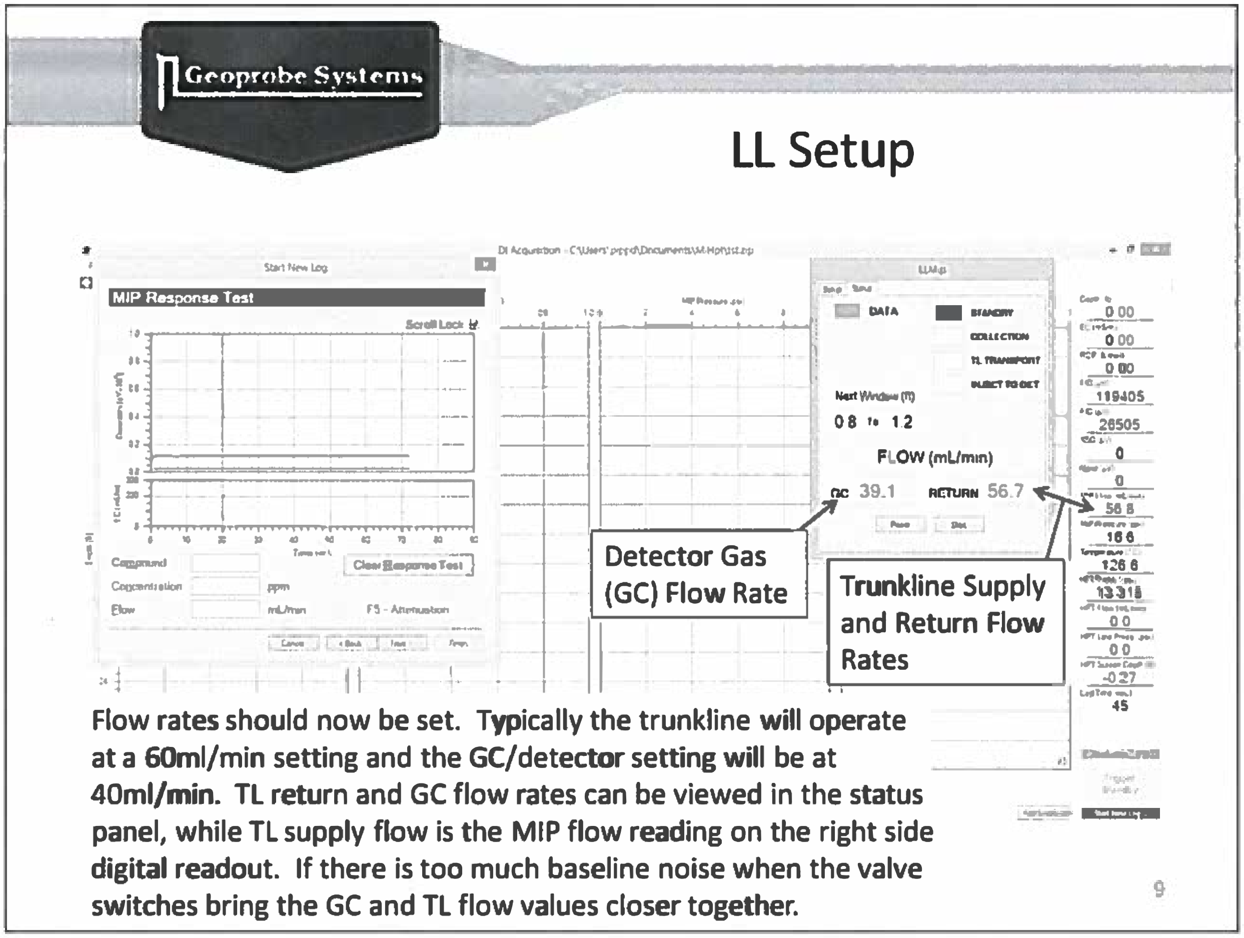


Software Setup

1 ft Length of Increment
0.2 ft Length of Window (+-)
2 s Time at Zero ROP
45 s No Flow Time
40 s Vent Runtime
15 s Inject to Detection

After selecting "Low Level MIP Mode" the LL MIP Setup panel will popup with a red validation button. Once the software successfully links communication with the control box the validation light will turn green. Note: the "mode" switch on the front panel of the MP9000 must be in the "automatic" position for linking to occur.

After the software recognizes that there is a MP9000 controller to link up to the LL MIP Control panel will show up. It will start with a red bar on the cycle times which will turn green when the software communicates with the controller on all of the LL cycle parameters. This can only happen if the LL controller mode switch is in automatic mode. If the controller mode switch is set to "manual mode" the validation button will remain red.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LL Setup

Next Window (ft) 0.8 to 1.2

GC 39.1 RETURN 56.7

Detector Gas (GC) Flow Rate

Trunkline Supply and Return Flow Rates

Flow rates should now be set. Typically the trunkline will operate at a 60ml/min setting and the GC/detector setting will be at 40ml/min. TL return and GC flow rates can be viewed in the status panel, while TL supply flow is the MIP flow reading on the right side digital readout. If there is too much baseline noise when the valve switches bring the GC and TL flow values closer together.

Make sure the trunkline and GC flow rates are set where you want them to be. They can be viewed on the LL MIP “Status” panel display. The MIP TL supply flow is noted on the right side under MIP flow and the return flow is on the LL Status panel next to return. The GC flow is listed to the right of GC.

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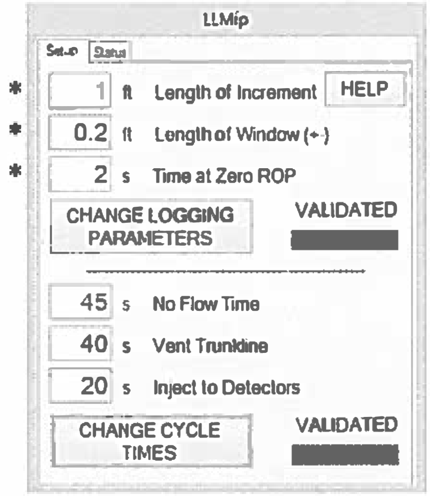
LL Setup



* 1 ft Length of Increment
* 0.2 ft Length of Window (+-)
* 2 s Time at Zero ROP

45 s No Flow Time
40 s Vent Trunkline
20 s Inject to Detectors

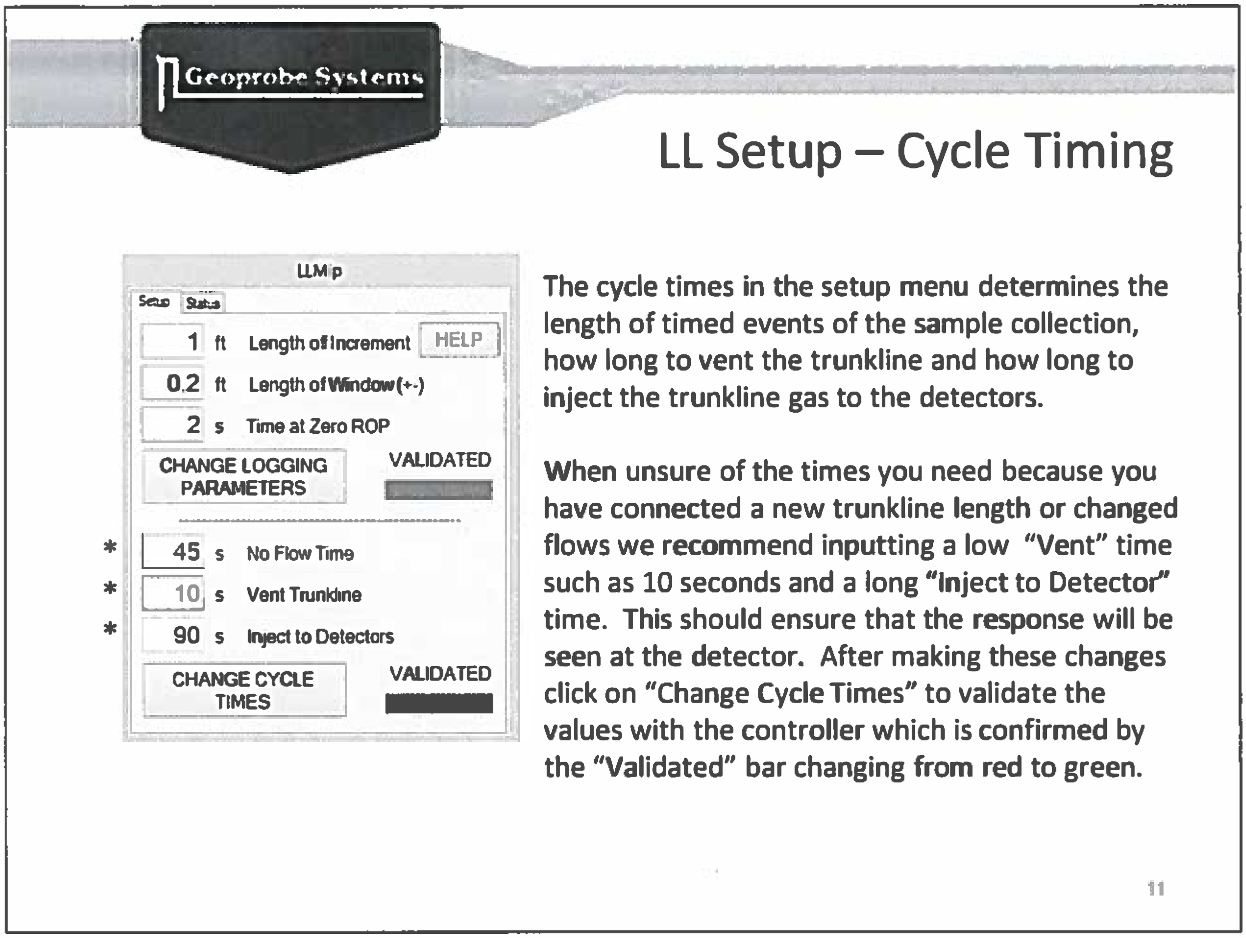
The logging parameters in the setup menu determine the frequency and requirements of the automatic start of the LL Cycles.

In this case sampling will occur every foot within a ± 0.2 window and with the rod advancement stopped for 2 seconds. So when we begin this log and the probe is stopped between 0.8'-1.2' for 2 seconds the LL cycle will automatically start.

You will want to keep the "Time at Zero ROP" low since the longer the time is the more contaminant is lost prior to the cycle starting.

Changing a value on the setup panel will require validation to the communicate the change with the controller.

The top half of the Setup tab on the LL MIP Panel display describes how frequent the LL cycles will occur as the tool is advanced into the soil. In this example the low level system will begin its programmed cycle every foot. For the LL automatic cycling to occur the rig operator needs to bring the tool to a stop (ROP = 0, for 2 sec) inside a ± 0.2' window surrounding every foot of depth. So the system will cycle when the probe is stopped between 4.8' and 5.2'. These units will change to metric (m and cm) when metric units are selected under the "view – units" tab at the top row of the DI acquisition software.



LL Setup – Cycle Timing

1 ft Length of Increment
0.2 ft Length of Window (+-)
2 s Time at Zero ROP

* 45 s No Flow Time
* 10 s Vent Trunkline
* 90 s Inject to Detectors

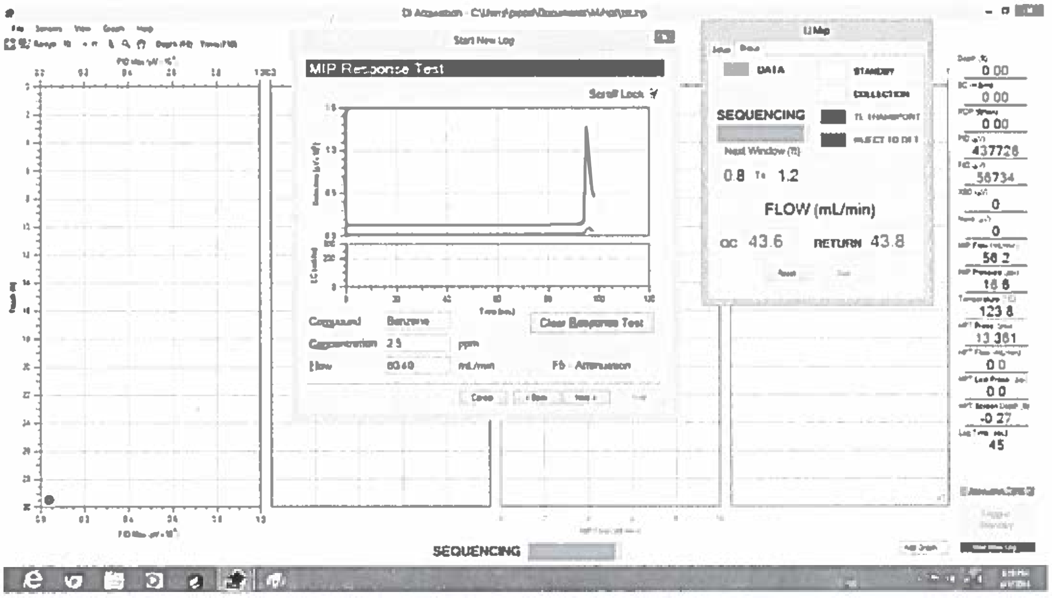
The cycle times in the setup menu determines the length of timed events of the sample collection, how long to vent the trunkline and how long to inject the trunkline gas to the detectors.

When unsure of the times you need because you have connected a new trunkline length or changed flows we recommend inputting a low "Vent" time such as 10 seconds and a long "Inject to Detector" time. This should ensure that the response will be seen at the detector. After making these changes click on "Change Cycle Times" to validate the values with the controller which is confirmed by the "Validated" bar changing from red to green.

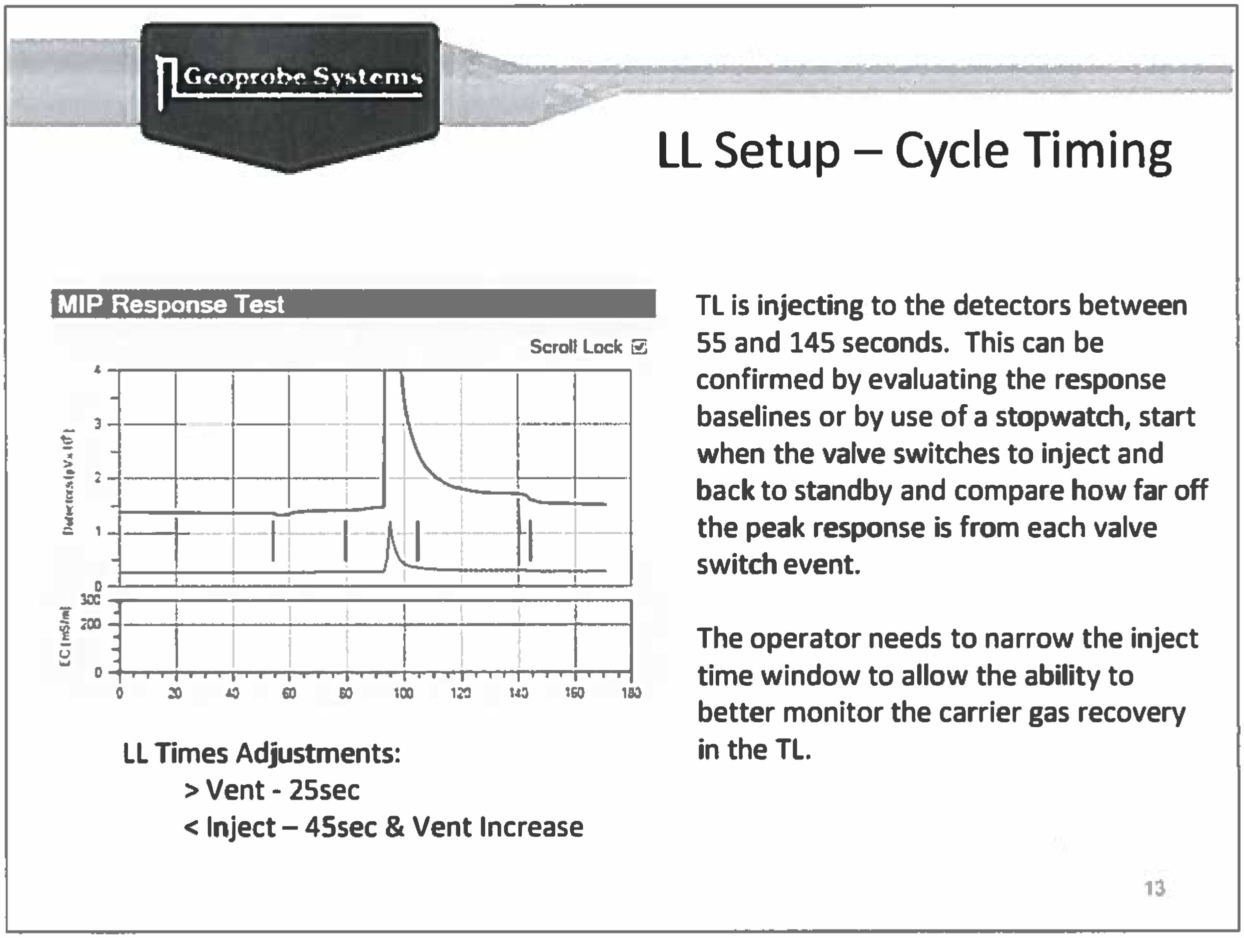
The lower portion of the "Setup" tab of the LL MIP Panel display describes how long each of the timed parameters of the LL cycle will occur. The No Flow time is the length of time sample is collected at the membrane. This occurs with no trunkline flow but the detectors are receiving clean carrier gas from the GC. When changing any of the values on this panel display the validation button will turn red until the change button is pressed which communicates the change to the hardware in the control box. The values entered here for the Vent and Inject Times are set to ensure that the operators will see the contaminant peak. These settings are only used on initial setup to "find" the peak.

Geoprobe Systems

LL Setup – Cycle Timing



Here is the response test which shows the contaminant peak showing up in the response test. The LL Status panel display shows both the TL trransport and Inject lights on as the TL carrier is directed to the detectors.



LL Setup – Cycle Timing

MIP Response Test

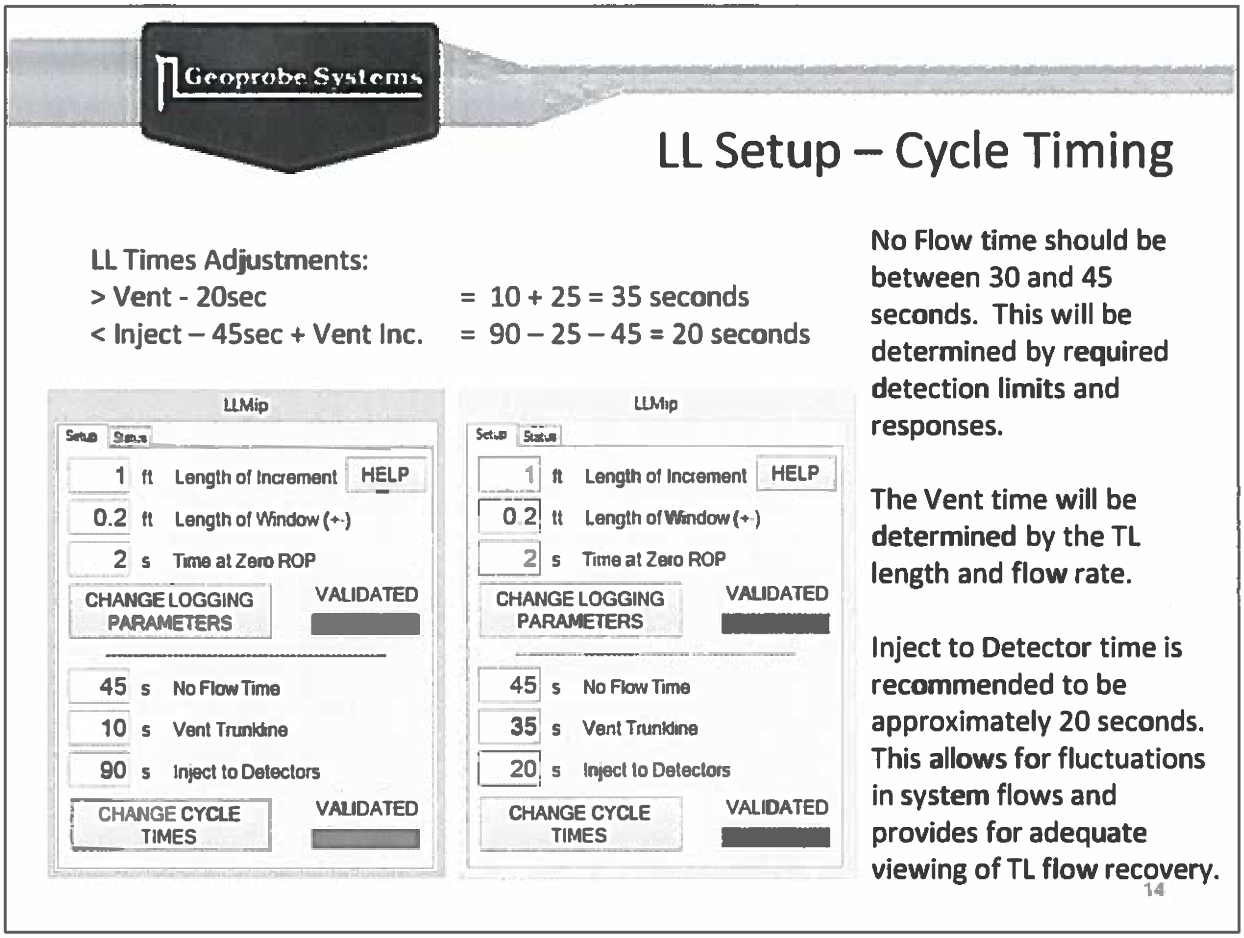
Scroll Lock ☑

LL Times Adjustments:
> Vent - 25sec
< Inject – 45sec & Vent Increase

TL is injecting to the detectors between 55 and 145 seconds. This can be confirmed by evaluating the response baselines or by use of a stopwatch, start when the valve switches to inject and back to standby and compare how far off the peak response is from each valve switch event.

The operator needs to narrow the inject time window to allow the ability to better monitor the carrier gas recovery in the TL.

This close up view of the baseline shows when the sample valve changed directing the TL gas to the detectors which occurred between 55 and 145seconds. For continual operation the vent time will be increased by 25 seconds and the inject time will be decreased by 45 seconds and by the 25 seconds added to the vent time.



Geoprobe Systems

LL Setup – Cycle Timing

LL Times Adjustments:
> Vent - 20sec = 10 + 25 = 35 seconds
< Inject – 45sec + Vent Inc. = 90 – 25 – 45 = 20 seconds

LLMip
Setup Status
1 ft Length of Increment
0.2 ft Length of Window (+-)
2 s Time at Zero ROP
VALIDATED
45 s No Flow Time
10 s Vent Trunkline
90 s Inject to Detectors
VALIDATED

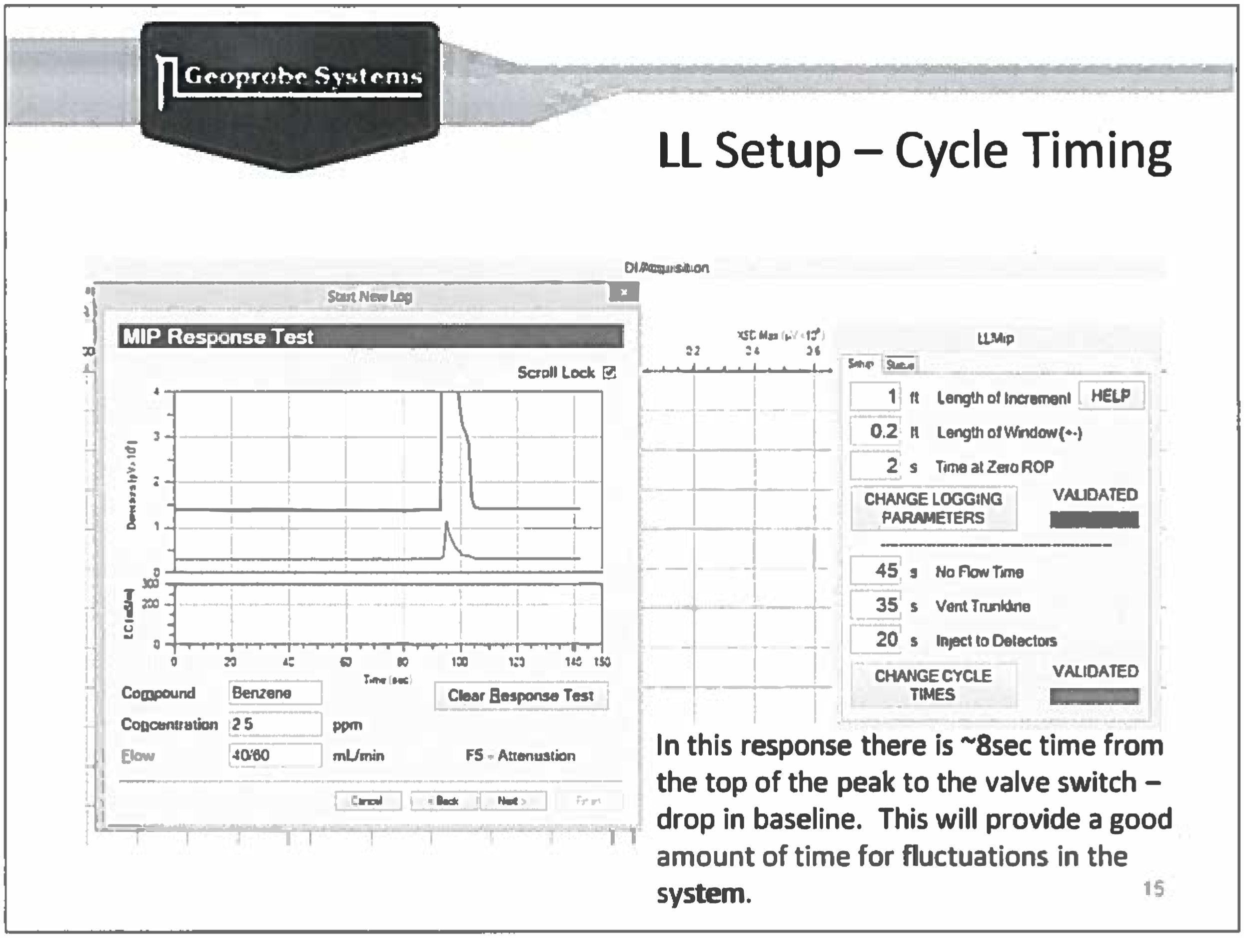
LLMip
Setup Status
1 ft Length of Increment
0.2 ft Length of Window (+-)
2 s Time at Zero ROP
VALIDATED
45 s No Flow Time
35 s Vent Trunkline
20 s Inject to Detectors
VALIDATED

No Flow time should be between 30 and 45 seconds. This will be determined by required detection limits and responses.

The Vent time will be determined by the TL length and flow rate.

Inject to Detector time is recommended to be approximately 20 seconds. This allows for fluctuations in system flows and provides for adequate viewing of TL flow recovery.

This shows the time adjustments made to the vent time (increased by 25 seconds) and to the inject time (decreased by 45+25 or a total of 70 seconds).



LL Setup – Cycle Timing

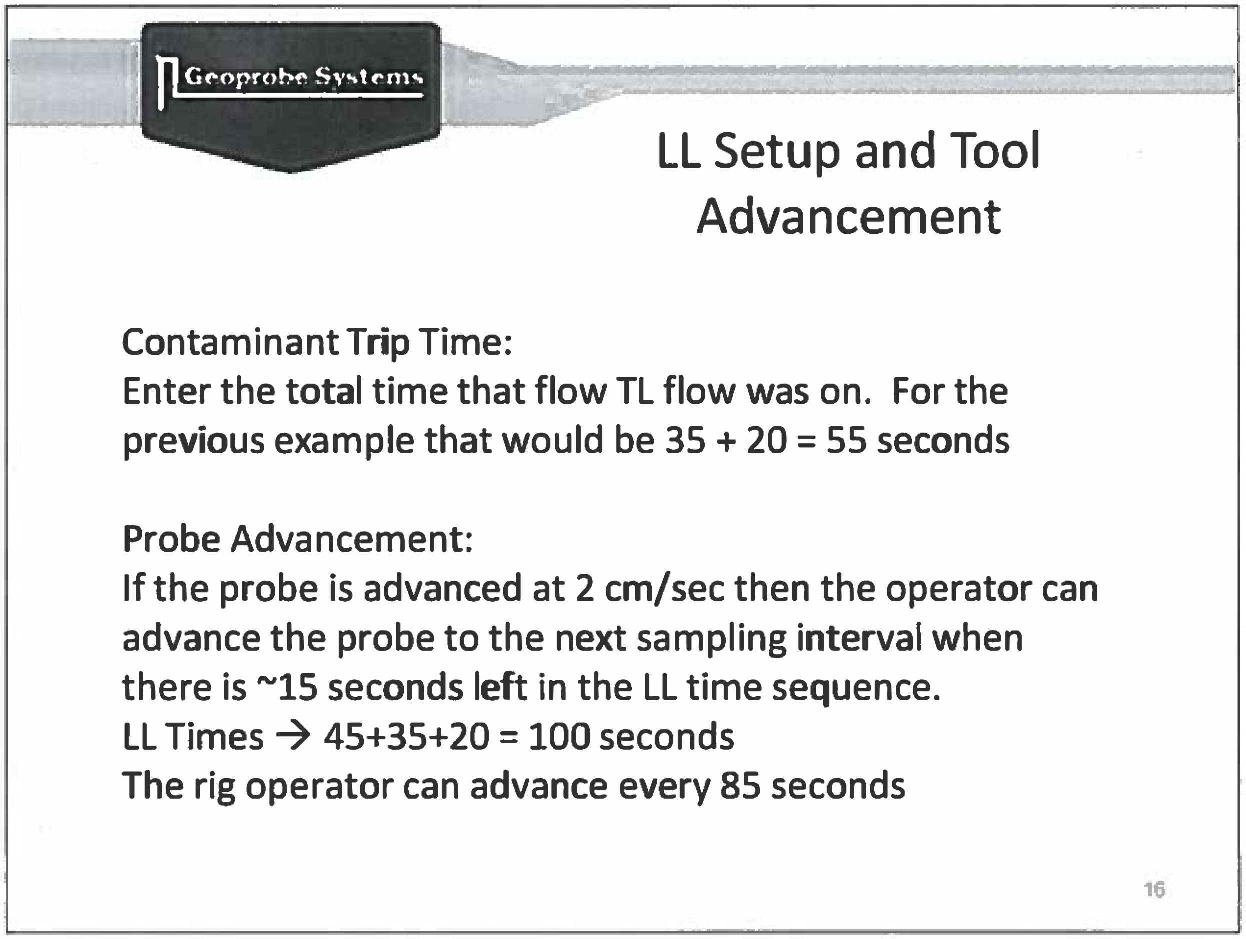
Compound: Benzene
Concentration: 25 ppm
Flow: 40/60 mL/min

1 ft Length of Increment
0.2 ft Length of Window (+-)
2 s Time at Zero ROP

45 s No Flow Time
35 s Vent Trunkline
20 s Inject to Detectors

In this response there is ~8sec time from the top of the peak to the valve switch – drop in baseline. This will provide a good amount of time for fluctuations in the system.

This is the response test run again using the new LL cycle time values. This shows plenty of time ahead of the peak response approximately 12 seconds and about 8 seconds after the top of the peak when the value switched back putting the LL Status back to Standby ready to collect the next sample. If too much time is left after the contaminant peak comes through the system then the operator will be wasting time waiting for the system to get back to standby when it can perform it's next sample collection. If the operator advances the probe to the next sampling interval and the system is not in standby or ready to collect the sample then the probe will be heating with the TL gas flowing thus removing any present contaminants which will be vented and not plotted in the depth graph possibly removing and eliminating a positive response.



Geoprobe Systems

LL Setup and Tool Advancement

Contaminant Trip Time:
Enter the total time that flow TL flow was on. For the previous example that would be 35 + 20 = 55 seconds

Probe Advancement:
If the probe is advanced at 2 cm/sec then the operator can advance the probe to the next sampling interval when there is ~15 seconds left in the LL time sequence.
LL Times → 45+35+20 = 100 seconds
The rig operator can advance every 85 seconds

The trip time entered should be the total of the LL Cycle vent and inject times.

This slide shows how frequent the probe can be advanced from the rig operator standpoint. How long the rig operator has to wait is determined by the TL vent and inject values used which is ultimately determined by the trunkline length and carrier gas flow. Shorter trunklines will be advanced quicker because there is less time waiting for the contaminant response to move to the surface.

APPENDIX C

Project Schedule

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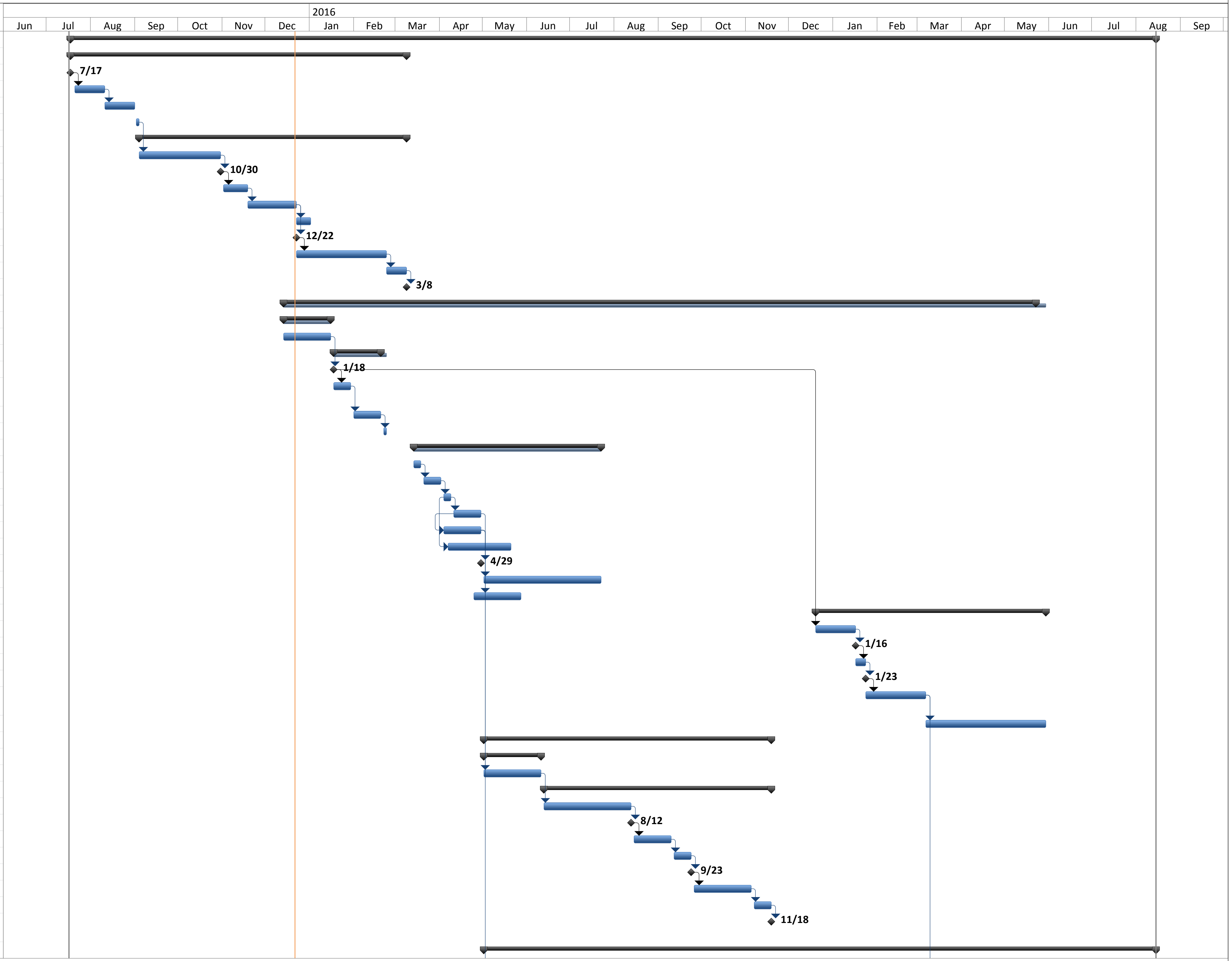
ARNG OMS #28

ID	Task Name	Duration	Start	Finish
1	**ARNG OMS #28**	**541 days**	**Fri 7/17/15**	**Mon 8/14/17**
2	**1.0 WORK PLAN**	**167 days**	**Fri 7/17/15**	**Tue 3/8/16**
3	Notice to Proceed	0 days	Fri 7/17/15	Fri 7/17/15
4	Project Setup and Internal Coordination	15 days	Tue 7/21/15	Mon 8/10/15
5	USACE & ARNG Coordination	15 days	Tue 8/11/15	Mon 8/31/15
6	Project Kick-Off	2 days	Wed 9/2/15	Thu 9/3/15
7	**1.1 UFP-QAPP and SSHP**	**133 days**	**Fri 9/4/15**	**Tue 3/8/16**
8	Prepare Draft QAPP/SSHP	41 days	Fri 9/4/15	Fri 10/30/15
9	1.1.1 Submit Internal Draft QAPP/SSHP	0 days	Fri 10/30/15	Fri 10/30/15
10	Army Review Internal Draft QAPP/SSHP	13 days	Mon 11/2/15	Wed 11/18/15
11	RTC Internal Draft QAPP/SSHP	24 days	Thu 11/19/15	Tue 12/22/15
12	Submit Army Final SSHP	8 days	Wed 12/23/15	Fri 1/1/16
13	1.1.2 Submit Regulator Final QAPP	0 days	Tue 12/22/15	Tue 12/22/15
14	ADEM Review Final QAPP	45 days	Wed 12/23/15	Tue 2/23/16
15	RTC Final QAPP	10 days	Wed 2/24/16	Tue 3/8/16
16	1.1.3 Submit Regulator Final QAPP	0 days	Tue 3/8/16	Tue 3/8/16
17	**2.0 FIELD INVESTIGATION**	**376 days**	**Mon 12/14/15**	**Mon 5/22/17**
18	**2.1. Pre-Field Investigation**	**25 days**	**Mon 12/14/15**	**Fri 1/15/16**
19	Procurement, Scheduling	25 days	Mon 12/14/15	Fri 1/15/16
20	**2.2. GW Sampling Event #1 - Mob 1**	**25 days**	**Mon 1/18/16**	**Fri 2/19/16**
21	2.2.1. Field Work Begins	0 days	Mon 1/18/16	Mon 1/18/16
22	Mob, Clearing, Well Inventory, Well Development, and Sampling	10 days	Mon 1/18/16	Fri 1/29/16
23	Off-Site Testing & Data Interpretation	15 days	Mon 2/1/16	Fri 2/19/16
24	Army Meeting - Mob#1 Data Evaluation	2 days	Mon 2/22/16	Tue 2/23/16
25	**2.3. Data Gap Investigation - Mobilization #2**	**95 days**	**Mon 3/14/16**	**Fri 7/22/16**
26	Sub Coordination & Mobilization	5 days	Mon 3/14/16	Fri 3/18/16
27	DPT - MIP/HPT/EC Soil Screening	10 days	Mon 3/21/16	Fri 4/1/16
28	DPT - Soil Screening/Sampling	5 days	Mon 4/4/16	Fri 4/8/16
29	DPT Groundwater Grab Sampling	15 days	Mon 4/11/16	Fri 4/29/16
30	On-Site Mobile Lab Testing	20 days	Mon 4/4/16	Fri 4/29/16
31	Off-Site Fixed Lab Testing	32 days	Thu 4/7/16	Fri 5/20/16
32	2.3.1. Field Work Ends	0 days	Fri 4/29/16	Fri 4/29/16
33	IDW Management	60 days	Mon 5/2/16	Fri 7/22/16
34	CSM Revision	25 days	Mon 4/25/16	Fri 5/27/16
35	**2.4. GW Sampling Event #2 - Mobilization #3**	**115 days**	**Tue 12/20/16**	**Mon 5/29/17**
36	Coordination and Scheduling	20 days	Tue 12/20/16	Mon 1/16/17
37	2.4.1. Field Work Begins	0 days	Mon 1/16/17	Mon 1/16/17
38	GW Sampling	5 days	Tue 1/17/17	Mon 1/23/17
39	2.4.2. Field Work Ends	0 days	Mon 1/23/17	Mon 1/23/17
40	Off-Site Analytical Testing (standard TAT TCL VOCs) & Data Interpretation	30 days	Tue 1/24/17	Mon 3/6/17
41	IDW Management	60 days	Tue 3/7/17	Mon 5/29/17
42	**3.0 RISK ASSESSMENT & REPORT**	**145 days**	**Mon 5/2/16**	**Fri 11/18/16**
43	**3.1. Risk Assessment**	**30 days**	**Mon 5/2/16**	**Fri 6/10/16**
44	Data Validation, Tables & Figures	30 days	Mon 5/2/16	Fri 6/10/16
45	**3.2 Risk Assessment Report**	115 days	Mon 6/13/16	Fri 11/18/16
46	Prepare Draft RA Report	45 days	Mon 6/13/16	Fri 8/12/16
47	3.2.2. Submit Internal Draft RA Report	0 days	Fri 8/12/16	Fri 8/12/16
48	Army Review Internal Draft RA Report	20 days	Mon 8/15/16	Fri 9/9/16
49	RTC Internal Draft RA Report	10 days	Mon 9/12/16	Fri 9/23/16
50	3.2.2. Submit Regulator Final RA Report	0 days	Fri 9/23/16	Fri 9/23/16
51	ADEM Review Final RA Report	30 days	Mon 9/26/16	Fri 11/4/16
52	RTC Final RA Report	10 days	Mon 11/7/16	Fri 11/18/16
53	3.2.3. Submit Regulator Revised Final RA Report	0 days	Fri 11/18/16	Fri 11/18/16
54	**4.0 REPORTS**	**336 days**	**Mon 5/2/16**	**Mon 8/14/17**

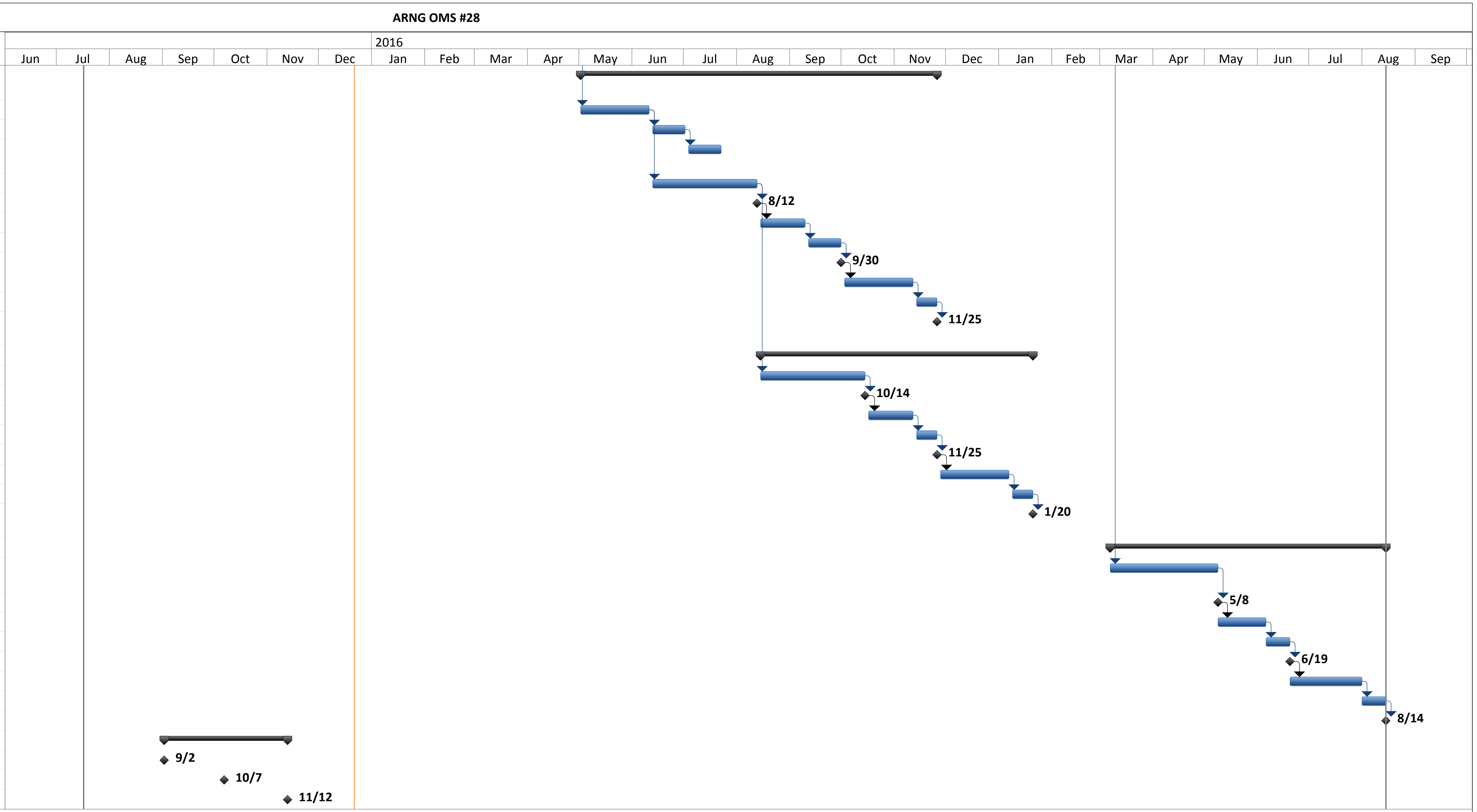


Project: ARNG OMS #28
Date: Tue 12/22/15

Task	▬	Summary	▬	External Milestone	◆	Inactive Summary	▭	Manual Summary Rollup	▬	Finish-only	]
Split	┈	Project Summary	▬	Inactive Task	▭	Manual Task	▬	Manual Summary	▬	Deadline	⬇
Milestone	◆	External Tasks	▬	Inactive Milestone	◇	Duration-only	▬	Start-only	[	Progress	▬

ARNG OMS #28

ID	Task Name	Duration	Start	Finish
55	**4.1. Groundwater Monitoring Report (GWMR) & Supplemental Data Gap Investigation (SDGI)**	150 days	Mon 5/2/16	Fri 11/25/16
56	Data Validation, ERIS, Tables & Figures	30 days	Mon 5/2/16	Fri 6/10/16
57	Conceptual Site Model 3-D visualization	15 days	Mon 6/13/16	Fri 7/1/16
58	3D Groundwater Flow and Solute Fate/Transport Modeling	15 days	Mon 7/4/16	Fri 7/22/16
59	Prepare Draft 1st GWMR	45 days	Mon 6/13/16	Fri 8/12/16
60	4.1.1 Submit Internal Draft 1st GWMR	0 days	Fri 8/12/16	Fri 8/12/16
61	Army Review Internal Draft 1st GWMR	20 days	Mon 8/15/16	Fri 9/9/16
62	RTC Internal Draft 1st GWMR	15 days	Mon 9/12/16	Fri 9/30/16
63	4.1.2 Submit Regulator Final 1st GWMR	0 days	Fri 9/30/16	Fri 9/30/16
64	ADEM Review Final 1st GWMR	30 days	Mon 10/3/16	Fri 11/11/16
65	RTC Final 1st GWMR	10 days	Mon 11/14/16	Fri 11/25/16
66	4.1.3 Submit Regulator Revised Final 1st GWMR	0 days	Fri 11/25/16	Fri 11/25/16
67	**4.2. Feasibility Study Evaluation Letter Report**	115 days	Mon 8/15/16	Fri 1/20/17
68	Prepare Draft FS Report	45 days	Mon 8/15/16	Fri 10/14/16
69	4.2.1 Submit Internal Draft FS Report	0 days	Fri 10/14/16	Fri 10/14/16
70	Army Review Internal Draft FS Report	20 days	Mon 10/17/16	Fri 11/11/16
71	RTC Internal Draft FS Report	10 days	Mon 11/14/16	Fri 11/25/16
72	4.2.2 Submit Regulator Final FS Report	0 days	Fri 11/25/16	Fri 11/25/16
73	ADEM Review Final FS Report	30 days	Mon 11/28/16	Fri 1/6/17
74	RTC Final FS Report	10 days	Mon 1/9/17	Fri 1/20/17
75	4.2.3 Submit Regulator Revised Final FS Report	0 days	Fri 1/20/17	Fri 1/20/17
76	**4.3. 2nd Groundwater Monitoring Report**	115 days	Tue 3/7/17	Mon 8/14/17
77	Prepare Draft GWMR, Data Validation, ERIS, Tables & Figures	45 days	Tue 3/7/17	Mon 5/8/17
78	4.3.1 Submit Internal Draft GWMR	0 days	Mon 5/8/17	Mon 5/8/17
79	Army Review Internal Draft GWMR	20 days	Tue 5/9/17	Mon 6/5/17
80	RTC Internal Draft GWMR	10 days	Tue 6/6/17	Mon 6/19/17
81	4.3.2 Submit Regulator Final GWMR	0 days	Mon 6/19/17	Mon 6/19/17
82	ADEM Review Final GWMR	30 days	Tue 6/20/17	Mon 7/31/17
83	RTC Final GWMR	10 days	Tue 8/1/17	Mon 8/14/17
84	4.3.3 Submit Regulator Revised Final GWMR	0 days	Mon 8/14/17	Mon 8/14/17
85	**5.0 MEETINGS**	**52 days**	**Wed 9/2/15**	**Thu 11/12/15**
86	5.1. Kick Off Meeting	0 days	Wed 9/2/15	Wed 9/2/15
87	5.2. Monthly Progress Meeting	0 days	Wed 10/7/15	Wed 10/7/15
88	5.3. TPP ADEM Meeting	0 days	Thu 11/12/15	Thu 11/12/15



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Task	▬	Summary	▬	External Milestone	◆	Inactive Summary	▭	Manual Summary Rollup	▬
Finish-only	⊐	Split	┈	Project Summary	▬	Inactive Task	▭	Manual Task	▬
Manual Summary	▬	Deadline	⬇	Milestone	◆	External Tasks	▬	Inactive Milestone	◇
Duration-only	▬	Start-only	⊏	Progress	▬				