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SAMPLING AND ANALYSIS PLAN SITE 89 DESIGN INVESTIGATION MCB CAMP LEJEUNE NC

11/01/2011

CH2M HILL

SAP Worksheet #1—Title and Approval Page

Final

Sampling and Analysis Plan
Site 89 Design Investigation

Marine Corps Base Camp Lejeune
Jacksonville, North Carolina

Contract Task Order WE17

November 2011

Prepared for

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic Division

Under the

NAVFAC CLEAN 8012 Program
Contract N62470-11-D-8012

Prepared by

CH2MHILL

Charlotte, North Carolina

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Executive Summary

This document presents the Uniform Federal Policy (UFP) Sampling and Analysis Plan (SAP) to conduct additional investigation activities in support of the remedial design at Installation Restoration Site 89 at Marine Corps Base Camp Lejeune (MCB CamLej), North Carolina.

CH2M HILL prepared this document under the United States (U.S.) Navy, Naval Facilities Engineering Command (NAVFAC) Atlantic Division, Comprehensive Long-Term Environmental Action - Navy (CLEAN) 8012 Contract N62470-11-D-8012, Contract Task Order (CTO) WE17 in accordance with the Navy's UFP-SAP policy guidance to ensure that environmental data collected are scientifically sound, of known and documented quality, and suitable for intended uses. The *Master Project Plans for Marine Corps Base Camp Lejeune* (CH2M HILL, 2008a) and the *Site Management Plan, Fiscal Year 2010, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina (*CH2M HILL, 2009a) provide additional information and background on MCB CamLej.

The purpose of this investigation is to provide data to refine the remedial designs for groundwater and surface water at Site 89. During the Feasibility Study (FS), groundwater at Site 89 was divided into two areas with different treatment strategies: the former Defense Reutilization and Marketing Office (DRMO) Area (active treatment) and Downgradient Area (passive treatment or monitoring). The requirement for active treatment was defined as concentrations of chemicals of concern (COCs) in groundwater exceeding industrial worker 10^{-4} cancer risk-based concentrations. COCs at Site 89 include the following chlorinated volatile organic compounds (VOCs): 1,1,2,2-tetrachloroethane (PCA), 1,1,2-trichloroethane (TCA), tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (DCE), trans-1,2-DCE, and vinyl chloride (VC). An area covering approximately 3.6 acres and a treatment depth of 70 feet below ground surface (bgs) was conservatively assumed based on analytical results collected from the existing monitoring well network. Vertical refinement of the depth required for active treatment will be completed by installing and sampling monitoring wells screened in the upper and middle Castle Hayne aquifer. Additionally, updated natural attenuation parameters, aquifer properties, and microbial data within the active treatment area were proposed to support the remedial design.

Surface water at Site 89 has been impacted by surficial groundwater discharging from the DRMO Area. Concerns were raised by the MCB CamLej Partnering Team about whether downgradient surficial groundwater was impacting Edwards Creek because surficial groundwater analytical results immediately upgradient of Edwards Creek exhibited elevated concentrations of COCs in the Downgradient Area. The most recent surface water sampling event indicated that the downstream portion of Edwards Creek contains COCs at concentrations exceeding North Carolina Surface Water Quality Standards. Pore water samples will be collected to provide data on the location and concentration of groundwater discharge in order to focus surface water remedial alternatives to the source area.

Activities for the Site 89 Design Investigation include:

- Installation of six monitoring wells screened in the upper Castle Hayne aquifer and six monitoring wells screened in the middle Castle Hayne aquifer
- Collection of groundwater samples from 20 monitoring wells (12 newly installed and 8 existing) screened within the Castle Hayne aquifer for analysis of COCs identified by the MCB CamLej Partnering Team and natural attenuation indicator parameters (NAIPs)
- Collection of 10 porewater samples from Edwards Creek for analysis of COCs identified by the MCB CamLej Partnering Team.

SAP Outline

This UFP-SAP consists of 37 worksheets specific to the scope of work for the Site 89 design investigation. All tables are embedded within the worksheets. All figures are included at the end of the document. The project-specific Health and Safety Plan (HASP) is included as **Attachment 1**. Field standard operation procedures (SOPs) are included in **Attachment 2**. Data management guidelines are included in **Attachment 3** and laboratory Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) letters are included in **Attachment 4**. Upon approval of this Draft SAP, the sampling activities will be scheduled and executed.

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2 Standard Operating Procedures—CH2M HILL
3 Data Management Guidelines
4 DoD ELAP Accreditation Letter – Analytical Laboratories

Figures

10-1 Site 89 Location Map
10-2 Conceptual Site Model
10-3 Groundwater and Pore water Sampling Locations

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Acronyms and Abbreviations

°C	degrees Celsius
µg/L	micrograms per liter
%R	percent recovery
AM	Activity Manager
amu	atomic mass unit
AQM	Activity Quality Manager
bgs	below ground surface
CA	Corrective Action
CAS	Chemical Abstract Service
CCV	continuing calibration verification
CLEAN	Comprehensive Long-Term Environmental Action - Navy
COC	chemical of concern
COD	coefficient of determination
CSM	conceptual site model
CT	cycle threshold
CTO	Contract Task Order
DCE	dichloroethene
DHC	Dehalococcoides
DL	detection limit
DNAPL	dense non-aqueous phase liquid
DoD	Department of Defense
DQI	Data Quality Indicator
DRMO	Defense Reutilization and Marketing Office
ELAP	Environmental Laboratory Accreditation Program
EMD	Environmental Management Division
EPA	United States Environmental Protection Agency
FID	flame ionization detector
FS	Feasibility Study
FTL	Field Team Leader
GC	gas chromatograph
H&S	Health and Safety
HASP	Health and Safety Plan
IC	ion chromatography
ICAL	initial calibration
ICP	inductively coupled plasma

ID	identification
IDW	investigation-derived waste
IS	internal standards
LCL	lower confidence limit
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MCB CamLej	Marine Corps Base Camp Lejeune
MCL	maximum contaminant level
mL	milliliter(s)
MS	matrix spike; mass spectrometer
MSD	matrix spike duplicate
NA	not applicable
NAIP	natural attenuation indicator parameter
NAVFAC	Naval Facilities Engineering Command
NCDENR	North Carolina Department of Environment and Natural Resources
NCGWQS	North Carolina Groundwater Quality Standards
NTCRA	non-time-critical removal action
NTR	Navy Technical Representative
ORP	oxidation-reduction potential
OU	Operable Unit
PAH	polycyclic aromatic hydrocarbon
PAL	project action limit
PCA	tetrachloroethane
PCE	tetrachloroethene
PDM	Project Data Manager
PE	Professional Engineer
PG	Professional Geologist
PID	photoionization detector
PIL	project indicator limit
PM	Project Manager
POC	point of contact
PQO	project quality objective
PVC	polyvinyl chloride
QA	quality assurance
QAMS	quality assurance management staff
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QL	quantitation limit
qPCR	quantitative polymerase chain reaction
QSM	Quality Systems Manual

RAO	Remedial Action Objective
RF	response factor
RI	Remedial Investigation
RNA	ribonucleic acid
RPD	relative percent difference
RPM	Remedial Project Manager
RRT	relative retention time
RSD	relative standard deviation
SAP	Sampling and Analysis Plan
SI	Supplemental Investigation
SOP	standard operating procedure
STC	Senior Technical Consultant
TBD	to be determined
TCA	trichloroethane
TCD	thermal conductivity detector
TCE	trichloroethene
TCRA	time-critical removal action
TM	Task Manager
TOC	total organic carbon
U.S.	United States
UCL	upper confidence limit
UFP	Uniform Federal Policy
UST	underground storage tank
VC	vinyl chloride
VOA	volatile organic analyte
VOC	volatile organic compound
WQP	water quality parameter
ZVI	zero valent iron

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SAP Worksheet #2—SAP Identifying Information

Site Name/Number: Site 89

Operable Unit: 16

Contractor Name: CH2M HILL

Contract Number: N62470-11-D-8012

Contract Title: Navy Comprehensive Long-Term Environmental Action - Navy (CLEAN) 8012

Work Assignment Number (optional):

1. **This Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of:**

   Guidance for Quality Assurance Project Plans (QAPPs) (United States [U.S.] Environmental Protection Agency [EPA], 2002)

   Quality Assurance (QA)/G-5, Quality Assurance Management Staff (QAMS) (EPA, 2002)

   Intergovernmental Data Quality Task Force Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP) (EPA, 2005)

   Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA, 2006)

2. **Identify regulatory program:** Comprehensive Environmental Response, Compensation, and Liability Act of 1980

3. **This SAP is a <u>Project-Specific</u> SAP**

4. **List dates of scoping sessions that were held:**

Scoping Session	Date
Partnering meeting	February 16, 2011
Partnering Meeting	August 16, 2011

SAP Worksheet #2—SAP Identifying Information (continued)

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

Title	Date
Remedial Investigation Work Plan, Site 89, Operable Unit (OU) 16, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina (CH2M HILL, 2003)	November 2003
Master Project Plans, Marine Corps Base Camp Lejeune, North Carolina (CH2M HILL, 2008a)	June 2008
Waste Management Plan, Marine Corps Base Camp Lejeune, Jacksonville, North Carolina (CH2M HILL, 2011a)	February 2011
UFP-SAP 2008 Comprehensive Groundwater Sampling- Site 89, OU 16, MCB CamLej, North Carolina (CH2M HILL, 2008b)	September 2008
UFP-SAP 2009 Supplemental Investigation, Site 89, OU 16, *MCB CamLej, North Carolina* (CH2M HILL, 2009b)	September 2009

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

- North Carolina Department of Environment and Natural Resources (NCDENR) (regulatory stakeholder)
- EPA Region 4 (regulatory stakeholder)
- Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic (lead organization)
- Marine Corps Base Camp Lejeune (MCB CamLej)

7. Lead organization:

U.S. Department of Navy – Lead Agency

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

Crosswalk table is excluded because all required information is provided in this SAP.

SAP Worksheet #3—Distribution List

Name of SAP Recipients	Title/Role	Organization	Telephone Number	E-mail Address or Mailing Address
Dave Cleland	Navy Technical Representative (NTR)	NAVFAC Mid-Atlantic	(757) 322-4851	david.t.cleland@navy.mil
Charity Rychak	Environmental Engineer	MCB CamLej- Environmental Management Division (EMD)	(910) 451-9385	charity.rychak@usmc.mil
Gena Townsend	Remedial Project Manager (RPM)	EPA Region 4	(404) 562-8538	townsend.gena@epa.gov
Randy McElveen	RPM	NCDENR	(919) 707-8341	randy.mcelveen@ncdenr.gov
Matt Louth	Activity Manager (AM)	CH2M HILL	(757) 671-6240	matt.louth@ch2m.com
Chris Bozzini	Activity Quality Manager (AQM)/ Senior Technical Consultant (STC)		(704) 544-5163	chris.bozzini@ch2m.com
Theron Grim	Project Manager (PM)		(704) 544-4065	Theron.Grim@ch2m.com
Brett Doerr	Navy CLEAN Program UFP-SAP Reviewer		(757) 671-6219	Brett.doerr@ch2m.com
Carl Woods	Health and Safety (H&S) Manager		(513) 889-5771	carl.woods@ch2m.com
Anita Dodson	Navy CLEAN Program Chemist		(757)671-6218	Anita.dodson@ch2m.com
Kristin Rogers	Task Manager (TM) and Field Team Leader (FTL)		(919) 760-1789	kristin.rogers@ch2m.com
Clairette Campbell	Project Chemist		(757) 671-6335	Clairette.Campbell@ch2m.com
Troy Horn	Project Data Manager (PDM)		(757) 671-6288	Troy.Horn@ch2m.com
Ronnie Wambles	Laboratory/PM	ENCO	(407) 826-5314	rwambles@encolabs.com
Anita Biernacki	Laboratory/PM	Microbial Insights	(865) 573-8188	anita.biernacki@microbe.com
Laura Maschhoff	Data Validator	DataQual Environmental Services	(314) 330-1327	dataqual@charter.net
To be determined (TBD)	Drilling Supervisor			
TBD	Utility Locating Supervisor			
TBD	Land Surveying Supervisor			

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SAP Worksheet #4—Project Personnel Sign-Off Sheet

Name	Organization/Title/Role	Telephone Number	Signature/ email receipt	Section Reviewed	Date SAP Read
Dave Cleland	NAVFAC-Mid Atlantic/ NTR	(757) 322-4851			
Charity Rychak	MCB CamLej/ EMD/Environmental Engineer	(910) 451-9385			
Gena Townsend	EPA Region 4/ RPM	(404) 562-8538			
Randy McElveen	NCDENR/ RPM	(919) 707-8341			
Matt Louth	CH2M HILL/ AM	(757) 671-6240			
Brett Doerr	CH2M HILL/Navy CLEAN Program UFP-SAP Reviewer	(757) 671-6219			
Theron Grim	CH2M HILL/ PM	(704) 544-4065			
Chris Bozzini	CH2M HILL/ AQM/STC	(704) 543-5163			
Carl Woods	CH2M HILL/ H&S Manager	(513) 889-5771			
Anita Dodson	CH2M HILL/Navy CLEAN Program Chemist	(757)671-6218			
Clairette Campbell	CH2M HILL/Project Chemist	(757) 671-6335			
Kristin Rogers	CH2M HILL/ TM/FTL	(919) 760-1789			
Troy Horn	CH2M HILL/ PDM	(757) 671-6288			
Ronnie Wambles	ENCO/Lab PM	(407) 826-5314			
Anita Biernacki	Microbial Insights/ Lab PM	(865) 573-8188			
Laura Maschhoff	DataQual/ Data Validator	(314) 330-1327			
TBD	Drilling Supervisor				
TBD	Utility Locating Supervisor				
TBD	Land Surveying Supervisor				

Note:

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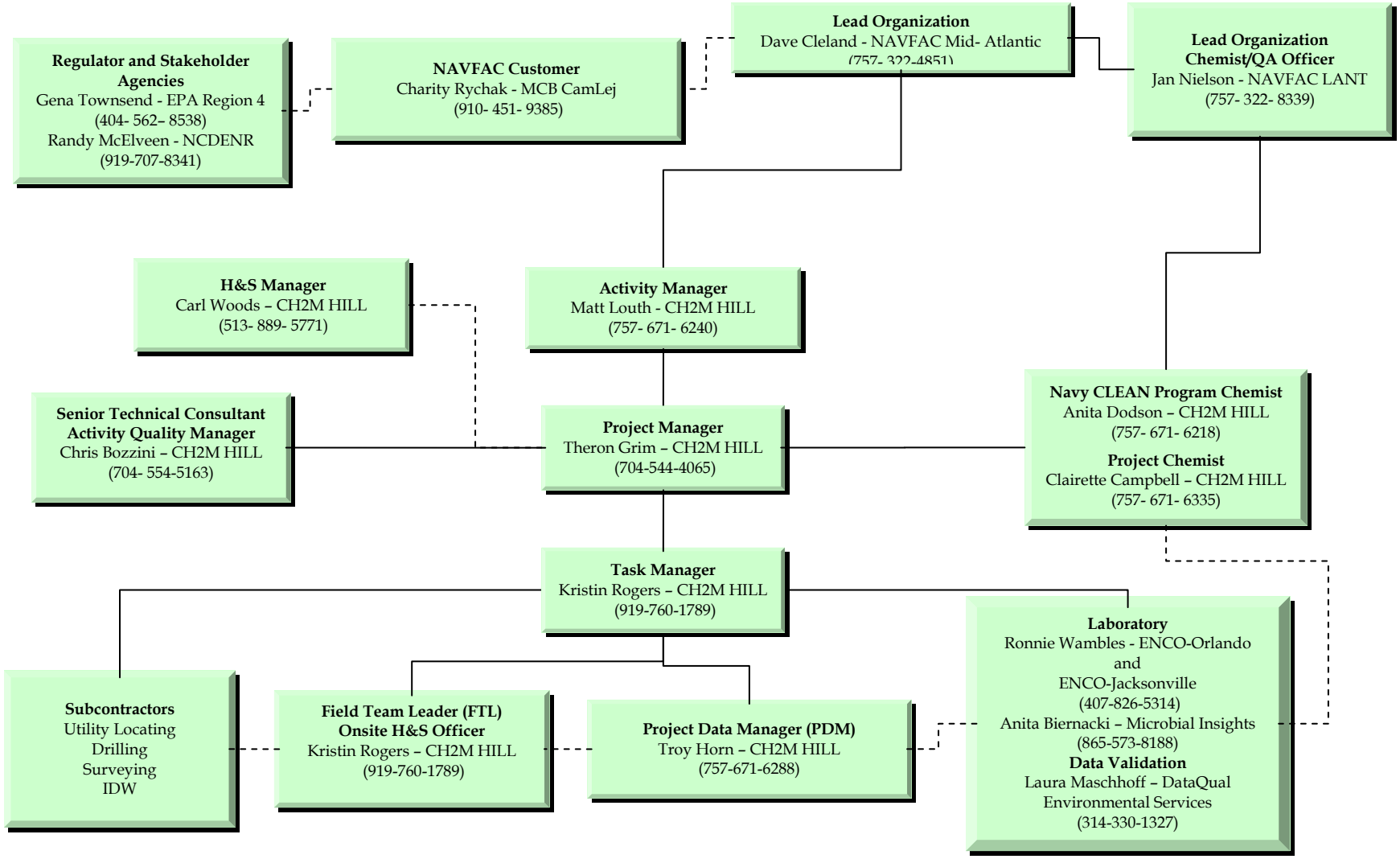
SAP Worksheet #5—Project Organizational Chart



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SAP Worksheet #6—Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure, Pathway, etc.
Communication with Navy (lead agency)	Navy NTR/RPM	Dave Cleland	david.t.cleland@navy.mil	Primary point of contact (POC) for Navy; can delegate communication to other internal or external POCs. RPM will notify EPA and NCDENR via email or telephone call within 24 hours if field changes affecting the scope or implementation of the design occur. Navy will have 10 days for work plan review. All sampling data will be presented and discussed during partnering meetings.
Communication with EPA Region 4	EPA Region 4 RPM	Gena Townsend	townsend.gena@epa.gov	Primary POC for EPA; can delegate communication to other internal or external POCs. Upon notification of field changes, EPA will have 24 hours to approve or comment on the field changes. All data results will be presented and discussed during partnering meetings.
Communication with NCDENR	NCDENR RPM	Randy McElveen	randy.mcelveen@ncdenr.gov	Primary POC for NCDENR; can delegate communication to other internal or external POCs. Upon notification of field changes, NCDENR will have 24 hours to approve or comment on the field changes.
Communication regarding overall project status and implementation and primary POC with Navy RPM, EPA, and NCDENR	CH2M HILL AM	Matt Louth	matt.louth@ch2m.com	Oversees project and will be informed of project status by the PM. If field changes occur, AM will work with the Navy RPM to communicate field changes to the team via email within 24 hours. All data results will be communicated to the project team during the first partnering meeting following data receipt.
Technical communications for project implementation, and data interpretation	CH2M HILL STC	Chris Bozzini	Chris.Bozzini@ch2m.com	POC regarding quality questions/issues encountered in the field, input on data interpretation, as needed. STC will have 24 hours to respond to technical field questions as necessary. Additionally, STC will review the data as necessary prior to partnering team discussion and reporting review.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure, Pathway, etc.
Communications regarding project management and implementation	PM	Theron Grim	Theron.Grim@ch2m.com	POC for field sampling team. All information and materials about the project will be forwarded to the Navy, AM, and STC as necessary.
Coordinate activities between PM and field team / subcontractors	TM	Kristin Rogers	kristin.rogers@ch2m.com	Responsible for field team members' and subcontractors adherence to work plan. All field team and reporting activities will be forwarded to PM for further dissemination if necessary.
Work plan changes in field. QAPP field changes/ field progress reports	FTL	Kristin Rogers	kristin.rogers@ch2m.com	Will provide documentation of field activities and work plan or QAPP deviations (made only with approval of the AM and/or Quality Assurance Officer (QAO) in field logbooks; will provide daily progress updates to PM.
H&S	Onsite H&S Officer	Kristin Rogers	kristin.rogers@ch2m.com	Responsible for field team members' adherence to the site safety requirements described in the Health and Safety Plan (HASP). Will report H&S incidents and near losses to PM.
Data tracking from field collection to database upload	PDM	Troy Horn	Troy.Horn@ch2m.com	Tracking data from sample collection through database upload.
Reporting lab data quality issues	ENCO-Orlando, ENCO-Jacksonville Microbial Insights	Ronnie Wambles Anita Biernacki	rwambles@encolabs.com abiernacki@microbe.com	All QA/quality control (QC) issues with project field samples will be reported within 2 days to the project chemist by the laboratory.
Reporting data validation issues	DataQual Environmental Services	Laura Maschhoff	dataqual@charter.net	All data validation issues regarding resubmissions from the laboratory will copy the CH2M HILL PDM on communications. The data validation report will be due to CH2M HILL within 14 calendar days of data receipt.

SAP Worksheet #6—Communication Pathways (continued)

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or e-mail	Procedure, Pathway, etc.
Field and analytical Corrective Actions (CAs)	Project Chemist	Clairette Campbell	Clairette.Campbell@ch2m.com	Any CAs for field and analytical issues will be determined by the FTL and/or the Project Chemist and reported to the PM within 4hrs.
Release of Analytical Data	Navy CLEAN Program Chemist/Project Chemist	Anita Dodson	anita.dodson@ch2m.com	No analytical data can be released until validation of the data is completed and has been approved by the Project Chemist. The project chemist will review analytical results within 7 days of receipt for release to the project team. The project chemist will immediately notify the PM, Navy RPM, and Navy QAO of any data quality issues that might cause the project quality objectives (PQOs) to not be obtained. The PM and RPM shall also be notified is there are significant delays by the laboratory that would cause significant project delivery issues.
Field CAs	TM and PM	Kristin Rogers Theron Grim	kristin.rogers@ch2m.com theron.grim@ch2m.com	Field and analytical issues requiring CA will be determined by the TM and/or PM; the PM will ensure QAPP requirements are met by the field staff.

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SAP Worksheet #7—Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities
Dave Cleland, Professional Geologist (PG)	NTR	NAVFAC Mid-Atlantic	Oversees project
Charity Rychak	Environmental Engineer	MCB CamLej/EMD	Oversees project
Matt Louth, PG	AM	CH2M HILL	Oversees project activities
Theron Grim, PG	PM	CH2M HILL	Manages project and coordinates project tasks and project staff
Brett Doerr	Navy CLEAN Program UFP-SAP Reviewer	CH2M HILL	Navy CLEAN Program UFP-SAP Reviewer
Chris Bozzini, Professional Engineer (PE)	AQM STC	CH2M HILL	Manages activity quality Provides technical oversight and review of technical work products and approaches
Carl Woods	H&S Manager	CH2M HILL	Prepares HASP; manages H&S for all field activities
Kristin Rogers	TM/FTL	CH2M HILL	Manages project tasks
Anita Dodson	Navy CLEAN Program Chemist	CH2M HILL	Program-level review of UFP-SAP and Program Chemist
Clairette Campbell	Project Chemist	CH2M HILL	Project chemist, coordinates with laboratory and data validator
Troy Horn	PDM	CH2M HILL	Data Management: manages sample tracking, communicates with laboratory and data validator
Ronnie Wambles Anita Biernacki	Laboratory Subcontractor PM	ENCO-Orlando ENCO-Jacksonville Microbial Insights	Manages samples tracking and maintains good communication with Project Chemist and PDM
Laura Maschhoff	Data Validator Subcontractor	DataQual	Validate data received from laboratory prior to use

[1] Resumes are maintained by the individuals' organizations and are available upon request; upon execution of the project, staff members may be removed (if unnecessary to project execution), and other staff members may be added or substituted, as necessary and available.

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SAP Worksheet #8—Special Personnel Training Requirements Table

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates

* - No special personnel training is required for this project.

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SAP Worksheet #9-1—Project Scoping Session Participation Sheet

Project Name: Site 89 Feasibility Study (FS) **Projected Date(s) of Sampling:** NA **PM (Contract Task Order [CTO]-WE17):** Theron Grim	**Site Name:** Site 89 **Site Location:** MCB CamLej, Jacksonville, North Carolina

Date of Session: February 16, 2011

Scoping Session Purpose: To review actions to-date, present preliminary results of recent comprehensive sampling, discuss Remedial Action Objectives (RAOs) and proposed remedial alternatives, and schedule for the FS.

Name	Title/Project Role	Affiliation	Phone #	E-mail Address
Dave Cleland	RPM	NAVFAC Mid-Atlantic	(757) 322-4851	david.t.cleland@navy.mil
Charity Rychak	RPM	EMD MCB CamLej	(910) 451-9385	charity.rychak@usmc.mil
Gena Townsend	RPM	EPA Region 4	(404) 562-8538	townsend.gena@epa.gov
Randy McElveen	RPM	NCDENR	(919) 707-8341	randy.mcelveen@ncdenr.gov
Matt Louth	AM	CH2M HILL	(757) 671-6240	matt.louth@ch2m.com
Chris Bozzini	QAM	CH2M HILL	(704) 544-5163	chris.bozzini@ch2m.com

Comments:

The Partnering Team discussed the current extent of chemicals of concern (COCs) in groundwater and surface water, reviewed the RAOs from 2006 and proposed 2011 RAOs. Concerns were raised about upwelling of contaminated groundwater in the downstream portion of Edwards Creek (East of White Street). A request was made to provide justification for monitored natural attenuation as an alternative (natural attenuation indicator parameter [NAIP] and microbial sampling).

Action Items: None

Consensus Decisions: None

SAP Worksheet #9-2—Project Scoping Session Participation Sheet

Project Name: Site 89 Supplemental Investigation (SI) **Projected Date(s) of Sampling:** December 2011 **PM (CTO-WE17):** Theron Grim	**Site Name:** Site 89 **Site Location:** MCB CamLej, Jacksonville, North Carolina

Date of Session: August 16, 2011

Scoping Session Purpose: To provide consensus on the sampling strategy from the partnering team

Name	Title/Project Role	Affiliation	Phone #	E-mail Address
Dave Cleland	RPM	NAVFAC Mid-Atlantic	(757) 322-4851	david.t.cleland@navy.mil
Charity Rychak	RPM	EMD MCB CamLej	(910) 451-9385	charity.rychak@usmc.mil
Gena Townsend	RPM	EPA Region 4	(404) 562-8538	townsend.gena@epa.gov
Randy McElveen	RPM	NCDENR	(919) 707-8341	randy.mcelveen@ncdenr.gov
Matt Louth	AM	CH2M HILL	(757) 671-6240	matt.louth@ch2m.com
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Comments:

The Partnering Team discussed the sampling strategy to refine the active treatment volume and determine the groundwater to surface water discharge points in Edwards Creek, in support of the FS and remedial design at Site 89.

Action Items: None

Consensus Decisions: For the UFP-SAP, the Team agreed to the Site 89 sampling approach to further refine treatment volumes as follows:

• Install 12 monitoring wells (6 Upper Castle Hayne aquifer and 6 Middle Castle Hayne aquifer)

• Sample new and select existing monitoring wells (20 total) and 10 pore water samples from Edwards Creek

• Analyze samples for select volatile organic compounds (VOCs): 1,1,2,2-tetrachloroethane (PCA), 1,1,2-trichloroethane (TCA), cis-1,2-dichloroethene (DCE), tetrachloroethene (PCE), trans-1,2-DCE, trichloroethene (TCE), and vinyl chloride (VC)

SAP Worksheet #10—Problem Definition

This section provides a summary of the site background, previous investigations, conceptual site model (CSM), and identifies the project data needs.

Introduction

Site 89 is located on Camp Geiger in the northwest portion of MCB CamLej (**Figure 10-1**). The Site 89 area has been in use since the early 1960s by the Base Motor Pool and the Defense Reutilization and Marketing Office (DRMO). The site is located on Camp Geiger, within Marine Corps Air Station New River. The chemicals of concern (COCs) at Site 89 for groundwater and surface water include: 1,1,2,2- PCA, 1,1,2-TCA, PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC. Site 89 is currently undergoing a FS to address groundwater and surface water contamination. In order to optimize the remedial design, additional investigation is required.

The objectives of this field activity are to:

- Refine the vertical extent of COCs in the groundwater
- Support the design of active treatment alternatives by collecting NAIPs, microbial data, and aquifer properties within the upper and middle Castle Hayne aquifer
- Identify the extent of COCs discharging from groundwater to Edwards Creek through pore water sampling to refine the surface water remedial design

Site History

The Base Motor Pool operated on the site until 1988, and historical records indicate that various solvents, such as acetone, TCE, and methyl ethyl ketone, were used for cleaning parts and equipment. In 1983, a steel 550-gallon underground storage tank (UST) was installed and used for the storage of waste oil until its removal in 1993. During removal, visible signs of contamination were observed and the contaminated soil was removed until groundwater was encountered. Other structures historically located in the former UST area include Building STC-867, used for the storage of hazardous soil, and a wash rack with an associated drain and oil and water separator.

The Defense Logistics Agency operated the DRMO from 1988 until 2000, during which time the site was used as a storage yard for scrap and surplus metal, electronic equipment, vehicles, rubber tires, and fuel bladders. These bladders, ranging in capacity from 600 to 20,000 gallons, were stored at the site in the early 1990s. The site has not been used since the DRMO relocated in 2000.

Previous Investigations

Previous investigations and actions at Site 89 are summarized in **Table 1**.

SAP Worksheet #10—Problem Definition (continued)

TABLE 1
Previous Investigations and Actions at Site 89

Previous Investigation/Action*	Date of Investigation	Investigation Activities
Remedial Investigation (RI) OU No. 16 (Sites 89 and 93) (Baker, 1998)	1996 -1997	Conducted RI to assess the presence or absence of contamination in groundwater, surface water, sediments, and subsurface soils. Chlorinated solvents were detected in soil, groundwater in the surficial and upper Castle Hayne aquifers within the DRMO area, and surface water and sediment in Edwards Creek.
Long-Term Monitoring and Immediate Response Field Effort (Baker, 1999)	1999	Conducted groundwater sampling at Site 89 under the basewide long-term monitoring program. During the April 1999 sampling event, 1,1,2,2-PCA was reported at a concentration of 30,000 micrograms per liter (µg/L) in the sample from surficial aquifer monitoring well IR89-MW02, which prompted an immediate response to re-sample the well and install additional wells to confirm and delineate groundwater and potential soil impacts. Results indicated the potential for dense non-aqueous phase liquid (DNAPL) in the eastern and southern portions of the DRMO area.
Additional Sampling (soil, groundwater, surface water and sediment) (Baker, 2000)	2000	Conducted additional investigations of soil, groundwater, surface water, and sediment in October and December 1999. Identified elevated VOC impacts in the soil vadose zone indicative of a source of groundwater and surface water contamination. A time-critical removal action (TCRA) was recommended to remove DNAPL from shallow soils in the southern DRMO area.
TCRA (OHM, 2000)	2000	Removed 24,000 tons of shallow (0 to 5 feet below ground surface [bgs]) VOC-affected soil and treated the soil using low temperature thermal desorption. Treatment was considered complete when confirmatory samples of the treated soil indicated that concentrations of 1,1,2,2-PCA were below 1 milligram per kilogram. An aeration system was installed in Edwards Creek just downstream of Site 89 to remove VOCs from surface water.
SI and Evaluation (CH2M HILL, Baker, and CDM, 2001)	2001	Investigated the horizontal and vertical extent of DNAPL of primary contaminants TCE and 1,1,2,2-PCA through soil, groundwater, surface water, and sediment sampling. The SI identified two DNAPL source zones affecting 25,000 cubic yards of soil in the southern portion of the DRMO area.
Electrical Resistance Heating Pilot Test (Shaw, 2005)	2003-2004	Conducted a pilot test of an electrical resistance heating system in the southern portion of the former DRMO to remove free-phase DNAPL from below the groundwater surface. The treatment area covered approximately 15,900 square feet and treated soil and groundwater to a depth of 19 to 26 feet bgs. An estimated 48,500 pounds of VOC contamination was removed and confirmatory soil sampling indicated that DNAPL was effectively removed in the pilot study area.

SAP Worksheet #10—Problem Definition (continued)

TABLE 1
Previous Investigations and Actions at Site 89

Previous Investigation/Action*	Date of Investigation	Investigation Activities
Comprehensive RI (CH2M HILL, 2008c)	2003-2006	Investigated the extent of chlorinated VOCs and semi-volatile organic compounds in groundwater, surface water, and sediments of Edwards Creek. The human health risk assessment concluded that the VOC-contaminated subsurface soil posed a risk to the potential future adult and child residents and that groundwater posed a risk to current industrial receptors and future residents. Soil exposure risks reported in the RI were driven by soil in the southern portion of the DRMO area at the suspected source of groundwater contamination. The screening level ecological risk assessment found concentrations of polycyclic aromatic hydrocarbons (PAHs) and pesticides that posed a potential risk to the benthic invertebrate community in the wetlands.
Treatability Studies (AGVIQ-CH2M HILL Joint Venture, 2008)	2006-2007	Implemented a treatability study to evaluate the performance and design of four remedial technologies in support of the FS: enhanced reductive dechlorination by injecting a sodium lactate and emulsified vegetable oil mixture, chemical reduction via zero valent iron (ZVI) injection using pneumatic fracturing, air sparging via a horizontal well, and a permeable reactive barrier using mulch/compost as backfill. Air sparging, enhanced reductive dechlorination, and the mulch permeable reactive barrier were considered successful in reducing VOCs in groundwater within the treatment areas. Chemical reduction was unsuccessful due to poor distribution of the ZVI despite the use of pneumatic fracturing.
SI (CH2M HILL, 2008d)	2008	Collected groundwater samples from four temporary wells and surface water samples from three locations in Edwards Creek, from the eastern portion of Site 89, to further delineate VOC impacts.
Baseline Ecological Risk Assessment for the Western Wetland (CH2M HILL, 2008e)	2008	Collected confirmatory soil and sediment samples to assess the extent of PAH and pesticide impacts that were driving the risks reported in the RI. Removal of the contaminated soil from the western wetland area was recommended.
Vapor Intrusion Evaluation (CH2M HILL, 2009c)	2008	Collected subslab soil gas and indoor air sampling in buildings TC860 and TC864, located immediately northwest of the former DRMO area, to assess potential vapor intrusion pathways. No current risks to human health from vapor intrusion of VOCs were expected, but vapor intrusion evaluation during surficial groundwater remediation was recommended based on previous soil vapor data collected during the air sparge treatability study.

SAP Worksheet #10—Problem Definition (continued)

TABLE 1
Previous Investigations and Actions at Site 89

Previous Investigation/Action*	Date of Investigation	Investigation Activities
Soil Mixing Non-Time-Critical Removal Action (NTCRA) (AGVIQ-CH2M HILL Joint Venture, 2010)	2007-2009	Treated source area DNAPL using by mixing ZVI and clay into impacted soil in the southern portion of the former DRMO area. Post-treatment soil samples within the mixing area indicated that subsurface soil impacts and associated risks from subsurface soil exposure were removed in the treatment area.
Western Wetland NTCRA (CH2M HILL, 2010)	2010	Removed soil and sediment with PAHs and pesticide concentrations that contributed to unacceptable ecological risks. Confirmatory samples verified that the cleanup levels had been achieved and any remaining ecological risks were considered minimal and acceptable.
FS, Site 89, OU No. 16 (CH2M HILL, 2011b)	2008-2011	Conducted several groundwater and surface water investigations to support the 2011 FS. In 2008, conducted comprehensive groundwater and surface water sampling for VOCs and NAIPs. In 2009, conducted a fate and transport study in the soil mixing area to monitor the migration of treated groundwater. The presence of VC and cis-1,2-DCE in surface water samples suggests that although detection of COCs in the upgradient wells is decreasing, the water discharging into Edwards Creek is still impacted by VOCs. In 2010, conducted a comprehensive groundwater and surface water sampling event to assess current site conditions after the Soil Mixing NTCRA was completed. Groundwater and surface water were found to have been impacted by VOCs. For the FS, the MCB CamLej Partnering Team agreed to actively treating COCs in groundwater exceeding the industrial worker 10^{-4} cancer risk-based concentrations to meet project RAOs. The Partnering Team agreed to rely on passive remediation to achieve project RAOs for COC concentrations less than risk-based concentrations. The approximate extent of groundwater concentrations exceeding the industrial worker 10^{-4} cancer risk-based concentration are shown on **Figure 10-2** in blue. In order to refine the volume of groundwater containing COCs at concentrations exceeding the industrial worker 10^{-4} cancer risk-based concentration, additional groundwater investigation was recommended. Concerns were raised by the Partnering Team about the location of impacted groundwater discharge to surface water. Pore water samples located in the upstream and downstream reaches of Edwards Creek were recommended to provide data on the location and concentration of groundwater discharge in order to focus surface water remedial alternatives to the source.

Notes:
*Documents listed are available in the Administrative Record and provide detailed information to support remedy selection at Site 89.

SAP Worksheet #10—Problem Definition (continued)

Conceptual Site Model

In order to define the problem, it is necessary to understand the CSM, which presents a summary of the various contaminant sources, release mechanisms, nature and extent of contaminants, fate and transport pathways for contaminants, and environmental receptors. The CSM for Site 89 is presented on **Figure 10-2.**

Site Characteristics

Site 89 encompasses approximately 50 acres, including the former DRMO area southeast of the intersection of G and 8th streets and a wooded area east of White Street (downgradient area). Edwards Creek flows through the southern portion of the site and eventually flows into the New River. The areas north of the DRMO area are generally developed with buildings, asphalt, and grass and occupied by the School of Infantry. The area surrounding the DRMO area to the west and south is primarily wetland along Edwards Creek. The downgradient area is generally undeveloped and covered in wetland and forest (**Figure 10-2**).

Site 89 is located within an interstream area and has little topographic relief. Stormwater from Camp Geiger is conveyed via manmade drainage ditches into the source of Edwards Creek. Surface water at Site 89 also drains into Edwards Creek. The elevation of the DRMO area is approximately 14 feet above mean sea level.

Potential Sources

The primary contaminants in the groundwater at Site 89 are chlorinated VOCs. Site 89 appears to have two main source areas: one in the southern portion of the former DRMO area (the former vehicle maintenance and storage area) and the other in the area of the former UST. The presence of VOCs within the surface water suggests that the contaminated groundwater is discharging into Edwards Creek.

Nature and Extent

The primary COCs at Site 89 are chlorinated VOCs in the groundwater and surface water. In 2010, comprehensive groundwater and surface water sampling was conducted to evaluate current conditions at the site.

Groundwater

Groundwater in the surficial and upper Castle Hayne aquifers has been impacted by two groups of chlorinated VOCs and their daughter products: ethanes (1,1,2,2-PCA and 1,1,2-TCA) and ethenes (PCE, TCE, cis- and trans-1,2-DCE, and VC). In the surficial aquifer, detected concentrations were highest in samples collected from monitoring wells in the former DRMO area.

The predominant chlorinated VOCs in the upper Castle Hayne aquifer are chlorinated ethenes. As in the surficial aquifer, the greatest concentrations were detected in samples from the northern and southern historical treatment areas, with concentrations decreasing in downgradient monitoring wells to the east and southeast. Generally, chlorinated VOCs were more prevalent and detected at higher concentrations in samples collected from the surficial aquifer wells than from the upper Castle Hayne aquifer samples.

SAP Worksheet #10—Problem Definition (continued)

Based on the uncertainty in contaminant concentration distribution in the upper and middle Castle Hayne aquifers in the DRMO area, the vertical extent of VOCs should be refined to better estimate and optimize treatment volumes.

Groundwater in the downgradient area of Site 89 (east of White Street) contains lower concentrations of COCs than the DRMO area and appears to be delineated in the vertical and horizontal directions. The plume appears to cross Edwards Creek in the downgradient area and potentially discharges into the surface water (**Figure 10-2**).

Surface Water

Edwards Creek, which flows through Site 89, has historically been impacted by VOCs. Results from the 2010 surface water sampling event exhibited elevated concentrations of VOCs in samples collected east of White Street and downstream of the DRMO area in exceedance of the North Carolina Surface Water Quality Standards. The COCs detected in exceedance of regulatory criteria during recent rounds of surface water include 1,1,2,2-PCA, 1,1,2-TCA, TCE, and VC.

Geology and Hydrogeology

Site 89 is underlain by undifferentiated sediments consisting primarily of fine, loose to medium dense sands with lesser amounts of silt and clay to approximately 20 to 25 feet bgs. Thin discontinuous lenses of silt and clay are also present in the undifferentiated formation.

The undifferentiated sediments at MCB CamLej are typically underlain by a laterally discontinuous semi-confining unit, the Belgrade Formation, or Castle Hayne Confining Unit, which generally consists of mostly fine sands, silts, and clays, with lesser amounts of shell fragments. The Belgrade Formation appears to be laterally discontinuous at Site 89.

The River Bend Formation underlies the Belgrade Formation and is composed of cemented sands, silt, shells, fossil fragments, and trace amounts of clay. Shells and cemented clasts are found within the silty sand from 20 to approximately 40 feet bgs, decreasing with depth. A layer of dense silty sand exhibiting a decrease in moisture content was encountered in borings at depths of approximately 40 to 45 feet bgs. Fine grained sands, silty sands, and clays were encountered to 70 feet bgs. Another layer of dense fine-grained sand and silt with a decrease in moisture content was present at approximately 70 feet bgs. The maximum depth of investigation at Site 89 was 90 feet bgs.

The surficial aquifer is underlain by the Castle Hayne Confining Unit (Belgrade Formation), which is laterally discontinuous at Site 89, providing hydrologic connectivity between the surficial aquifer and the Castle Hayne aquifer, which underlies the Castle Hayne Confining Unit. The water table was encountered at depths ranging from approximately 3 to approximately 9 feet. The direction of groundwater flow within the surficial aquifer and the upper and middle Castle Hayne aquifers is to the south and east.

SAP Worksheet #10—Problem Definition (continued)

Exposure Pathways and Receptors

The human health risk assessment conducted during the Comprehensive RI indicated that potential unacceptable risk to current workers and future residents driven by exposure to VOCs in groundwater were present at Site 89. Currently the only activities occurring at the site are related to environmental investigation. Based on current concentrations and risk assessment results, future site use is likely to be restricted to industrial.

As a result, remediation goals based on industrial worker risks were selected by the MCB CamLej Partnering team, as discussed in **Table 1**.

Although risk to human health receptors from vapor intrusion is considered to be within acceptable limits under current site use, monitoring of soil gas, indoor air, and the subslab is recommended to ensure that surficial groundwater remediation is not creating vapor intrusion risks in the DRMO area.

All ecological risks are considered within acceptable levels.

Fate and Transport

The VOCs detected in groundwater at Site 89 are generally considered to be mobile through porous media. Based on the known/assumed distribution of VOCs in groundwater, their physical and chemical properties, and the direction of groundwater flow, VOCs from Site 89 are likely discharging to Edwards Creek in the southern portion of the DRMO area and potentially in the eastern portion of the site downgradient of the DRMO area (**Figure 10-2**).

The questions and problems to be addressed by this investigation include:

1. **What is the vertical distribution of COCs in groundwater in the area selected for active treatment?** This question will be addressed by installing six groundwater monitoring wells screened within the upper Castle Hayne aquifer, and six wells screened within the middle Castle Hayne aquifer, located within the DRMO area, as shown on **Figure 10-3**. Groundwater samples will be collected from each well for analysis of selected VOCs.

2. **Where and to what extent is impacted groundwater discharging into Edwards Creek?** This question will be addressed by collecting 10 pore water samples along the north side of Edwards Creek for VOC analysis, as shown on **Figure 10-3**. Pore water results will be compared to recent surface water concentrations and surficial groundwater concentrations to assess the likeliness of groundwater discharge being the source of surface water impacts.

3. **Do NAIPs suggest that reductive dechlorination is favorable?** This question will be addressed by analyzing for NAIPs (alkalinity, chloride, sulfide, sulfate, nitrite, nitrate, ferrous iron, total iron, manganese, dissolved gases: methane, ethane, ethene, and total organic carbon [TOC]) in samples collected from 12 new and 8 existing monitoring wells.

SAP Worksheet #10—Problem Definition (continued)

4. **Are microbial populations in groundwater within the upper and middle Castle Hayne aquifers in the active treatment area favorable for biodegradation?** This question will be addressed by conducting microbial analysis on samples collected from four groundwater monitoring wells screened within the upper Castle Hayne aquifer (IR89-MW53IW and IR89-MW17IW) and middle Castle Hayne aquifer (IR89-MW53DW and IR89-MW80DW) in the active treatment area.

5. **Are the aquifer properties within the active treatment area conducive to remedial actions that may include injection of air or other fluid as part of the treatment option?** This question will be addressed by conducting slug tests on 10 new and existing monitoring wells to provide empirical data on aquifer properties within the active treatment area.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements

This section presents the PQOs for the groundwater and pore water sampling.

Who will use the data?

The data will be used by the MCB CamLej Partnering Team to evaluate the extent of groundwater that will be subject to active treatment in the DRMO area and to support the remedial design for Site 89.

What are the project action limits?

The project action limits (PALs) are based on established criteria as agreed to by the Partnering Team.

Groundwater

- For the purpose of defining the extent of active treatment, concentrations of COCs detected in the groundwater will be compared to industrial worker 10^{-4} cancer risk-based concentrations:
    - 1,1,2,2-PCA = 31.0 µg/L
    - TCE = 587.0 µg/L
    - PCE = 24 µg/L
    - VC = 31.9 µg/L.

  1,1,2-TCA, cis-1,2-DCE, and tran-1,2-DCE were retained as COCs because they are daughter products of the primary COCs. The PALs for these chemicals are the North Carolina Groundwater Quality Standards (NCGWQS) or maximum contaminant levels (MCLs) provided in **Worksheet #15**.

Pore Water

- For the purpose of determining whether groundwater is discharging into Edwards Creek, concentrations of COCs detected in the pore water samples will be compared to the applicable North Carolina Surface Water Quality Standards.

What types of data are needed and how will the data be used?

- **Worksheet #15** defines the matrixes and analytes for Site 89. Analytical VOC results will be used to refine the vertical extents of the impacted groundwater in the former DRMO area. Additionally, data collected during this event will identify to what extent groundwater is discharging into Edwards Creek. NAIP parameters will be analyzed to further assess lines of evidence for natural attenuation processes.
- Water quality parameters (WQPs), including field testing for pH, conductivity, oxidation-reduction potential (ORP), dissolved oxygen, temperature, and turbidity will be collected during the purging of the monitoring wells. These data will be used for field QC to ensure that groundwater samples are representative of the water-bearing formation. They will also be used to assess lines of evidence for natural attenuation processes in the impacted area.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

- Lithologic logging will be conducted during drilling operations. The logging activities will facilitate selection of well screen intervals and supplement the CSM. Soil characteristics will be used to support the CSM.
- Hydraulic slug testing will be conducted to provide empirical hydraulic conductivity data for the surficial and Castle Hayne aquifers.
- Microbial analyses will be performed on four groundwater samples to assess whether conditions are favorable for biodegradation.
- Horizontal and vertical coordinates for monitoring well locations will be surveyed by a North Carolina-licensed surveyor to support spatial analysis of VOC impacts to groundwater.
- Horizontal coordinates for pore water sample locations will be recorded using a hand-held global positioning system device to support spatial analysis of VOC impacts to surface water.
- Field activities will be recorded in a field notebook to document adherence to the approved work plan. The CH2M HILL Preparing Field Log Books standard operating procedure (SOP) in **Attachment 2** describes the necessary documentation required for log book completion.

How "good" do the data need to be in order to support the environmental decision?

- The data need to be of sufficient quality for determining the concentration of constituents in media collected such that the project objectives can be achieved. Laboratory analytical data for VOCs will be distributed to a third-party validator for data quality evaluation. Data validation procedures and requirements for each analytical group are detailed in **Worksheets #34-36**.
- In order to collect groundwater samples that are representative of the water-bearing formations being monitored, groundwater monitoring wells must be constructed in accordance with the CH2M HILL Installation of Monitoring Wells by Sonic Drilling SOP (**Attachment 2**), and samples collected in accordance with the Collection of Groundwater Samples SOP (**Attachment 2**).
- During the groundwater investigation, QA/QC samples will be collected along with the various media samples as a check on sampling and analytical protocol. **Worksheet #20** describes the quantities and appropriate analyses to be conducted during sampling activities outlined in this SAP.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

How much data should be collected?

The number of samples and rationale is provided as follows and presented on **Figure 10-3**:

- A total of 20 groundwater samples are proposed from 8 existing and 12 newly installed monitoring wells.
  - Proposed monitoring wells are located within the active treatment zone where data is not present for the upper and middle Castle Hayne aquifer zones. Analytical COC results will be used to further refine the depth that will require treatment and optimize the treatment design. NAIP and microbial results will be used to provide lines of evidence for natural attenuation processes in the treatment area.
- A total of 10 pore water samples are proposed in Edwards Creek.
  - Pore water samples are spaced evenly in Edwards Creek in the region where groundwater is most likely discharging. Analytical results will be used to refine the surface water remedial design. Pore water results will also be used to assess the validity of the downgradient surficial aquifer plume.
- A total of 10 slug tests will be conducted on wells screened within the upper and middle Castle Hayne aquifers within the active treatment area to provide empirical data of the aquifer properties in support of the remedial design.

Where, when, and how should the data be collected/generated?

- The proposed investigation will be conducted in November and December of 2011.
- The environmental samples will be collected in accordance with the SOPs presented in **Worksheet #21**. Groundwater sampling will be collected using low-flow purging methods to the maximum extent possible.

Who will collect and generate the data? How will the data be reported?

- CH2M HILL personnel will collect environmental samples, including groundwater and pore water, as outlined in **Worksheets #10 and #18**.
- Borehole drilling, monitoring well installation, and well development will be performed by a North Carolina-licensed well drilling subcontractor with oversight provided by CH2M HILL personnel.
- Surveying of monitoring well locations and top of casing elevations will be performed by a North Carolina-licensed surveyor with oversight provided by CH2M HILL personnel.
- Laboratory analytical services will be provided by ENCO-Orlando, ENCO-Jacksonville, and Microbial Insights, under subcontract to CH2M HILL.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

- Once generated, analytical data for VOCs will be submitted to DataQual Environmental Services for validation against analytical methodology requirements and measurement performance criteria presented in this SAP.
- CH2M HILL will receive validated data and upload the data into a centralized electronic database used for Navy projects by the project team(s).
- Data will be reported in a summary technical memorandum, which will be submitted to the Navy and MCB CamLej as a draft for review before distribution to NCDENR and EPA for review and approval.

How will the data be archived?

Data will be archived according to the Navy CLEAN program/contract requirements. Data will be uploaded into the Naval Installation Restoration Information Solution database developed and maintained by CH2M HILL and used for Navy projects. At the end of the project, paper copies of archived laboratory data and validation reports will be returned to the Navy.

SAP Worksheet #11—Project Quality Objectives/Systematic Planning Process Statements (continued)

PQOs listed in the form of if/then qualitative and quantitative statements.

The following decision analysis process presents the PQOs for the environmental data collected from the site. The general objective of the decision analysis process is to evaluate whether the data collected meets the PQOs or if further investigations or actions are warranted.

Groundwater

If groundwater samples collected from the sampling interval within the Castle Hayne aquifer contain concentrations of VOCs below the PALs, then the treatment volume can be considered sufficiently delineated at that point in the DRMO area.

If a groundwater samples collected from the sampling interval Castle Hayne aquifer interval contain concentrations of VOCs above the PALs, then additional data may be required to refine the treatment depth in the DRMO area.

If NAIP results and bacterial populations indicate favorable conditions for natural attenuation within the treatment area, then the results will be taken into consideration for the remedial design.

Pore Water

If a pore water sample contains concentrations of COCs that exceed the PALs, then it is likely that groundwater is a source of surface water impacts at that location in Edwards Creek.

If a pore water sample contains concentrations of COCs that are below the PALs, it is not likely that impacted groundwater is a source of surface water impacts at that location in Edwards Creek.

If a pore water sample located east of White Street contains concentrations of COCs that exceed the PALs, then the surface water remedial alternative will be revisited to assess the effectiveness of the remedy to treat the downgradient groundwater as source of surface water contamination.

If a pore water sample located east of White Street does not contain concentrations of COCs that exceeds the PALs, then surface water remedial alternatives will be revisited to focus on upstream surface water as a source.

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SAP Worksheet #12-1—Field Quality Control Samples

Matrix: Groundwater, Pore Water

Analytical Group: VOCs

Concentration Level: Medium

QC Sample	Analytical Group	Frequency	Data Quality Indicator (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
Field Duplicates	VOCs	One per 10 field samples of similar matrix[1]	Precision	Same as Matrix Spike Duplicate (MSD), refer to **Worksheet #28-1**	S&A
Equipment Rinsate Blank		One per day of sampling per type of equipment used	Contamination/bias	Same as Method Blank, refer to **Worksheet #28-1**	S&A
Trip Blank		One per cooler to the laboratory containing VOCs	Contamination/bias		S&A
Cooler Temperature Blank		One per cooler to the laboratory	Accuracy / representativeness	0-6 degrees Celsius (°C)	S

[1] Groundwater and pore water are considered separate matrices.

SAP Worksheet #12-2—Field Quality Control Samples

Matrix: Groundwater

Analytical Group: NAIPs (dissolved gases, metals, wet chemistry), Microbials

Concentration Level: Medium

QC Sample	Analytical Group	Frequency	DQIs	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A), or both (S&A)
Cooler Temperature Blank	NAIPs (dissolved gases, metals, wet chemistry), Microbials	One per cooler to the laboratory	Accuracy / representativeness	0-6 °C	S

SAP Worksheet #13—Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator(s)	How The Data Will Be Used	Limitations on Data Use
2010, groundwater and surface water results	CH2M HILL, 2011b – *Feasibility Study Site 89, Operable Unit No.16, Marine Corps Base, Camp Lejeune, Jacksonville, North Carolina.*	CH2M HILL	Sample location selection, analysis selection, comparison with new data	Sample media were limited to surface water and groundwater.

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SAP Worksheet #14—Summary of Project Tasks

Pre-mobilization Tasks

- Procure subcontractor(s).
- Schedule field and support staff.
- Procure or rent all equipment and bottleware.
- Ensure that all SOPs and the HASP are in place for field tasks.

Field Tasks

The field investigation will accomplish the project objectives through the following activities, which will be conducted in accordance with CH2M HILL SOPs (Attachment 2) and the Master Project Plans (CH2M HILL, 2008a).

Mobilization

The mobilization period will include identifying, briefing, and mobilizing personnel, as well as securing and deploying equipment. Mobilization activities include general activities and a kickoff and site safety meeting

General Activities

- Identify and procure, package, ship, and inventory project equipment, hand tools, and supplies.
- Coordinate with local agencies, including the Marine Corps, police, and fire department, as appropriate.
- Finalize operating schedules.
- Test and inspect equipment.
- Conduct site-specific training on the HASP and hazards.
- Review subcontractor Activity Hazard Analysis forms.
- Verify that all forms and project documentation are in order and project team members understand their responsibilities regarding project reporting requirements.

Kickoff/Safety Meeting

During mobilization, a kickoff and site safety meeting will be conducted. This meeting will include a review of this SAP and review and acknowledgment of the HASP by all site personnel. Additional meetings will occur as needed, as new personnel, visitors, and/or subcontractors arrive at the site.

SAP Worksheet #14—Summary of Project Tasks (continued)

Utility Clearance

Before intrusive sampling activities begin, North Carolina One-call will be notified of field activities, and all buried utilities will be identified and marked within a 20-foot radius by a subcontracted utility locator. Each intrusive sampling location will be cleared of utilities with a hand auger to a minimum depth of 5 feet bgs, as indicated in Utility Locating SOP (**Attachment 2**).

Land Surveying

Land surveying will be conducted during the environmental field sampling and will entail surveying of the horizontal coordinates and ground and top-of-casing elevations of the 12 new monitoring wells, up to 10 existing monitoring wells, and 10 pore water sampling locations. Land surveying services will be provided by a North Carolina- licensed surveyor in accordance with Section 3.3 of the Master Project Plans (CH2M HILL, 2008a).

Monitoring Well Installation

- Six Type III-equivalent groundwater monitoring wells will be screened within the upper Castle Hayne aquifer (50 feet bgs) and six Type III-equivalent groundwater monitoring wells will be screened within the middle Castle Hayne aquifer (90 feet bgs) using rotosonic drilling methods following the monitoring well installation procedures found in **Attachment 2**.
- The soil cores recovered from the rotosonic core barrel will be used to describe site lithology and to screen for the presence of VOCs, in accordance with guidelines found in **Attachment 2.**
- The screened interval of each well will consist of a 5-foot length of 2-inch inner diameter 0.010-inch machine-slotted Schedule 40 polyvinyl chloride (PVC).
- The annular space between the PVC and borehole wall will be completed according with North Carolina Well Construction Standards (15A North Carolina Administrative Code 2C). The sand filter pack will extend to approximately 2 feet above the top of the screened interval. Sodium bentonite pellets will be placed above the sand pack to form a seal of approximately 5 feet thick. The grout seal will be placed and will extend from the top of the bentonite seal to approximately 1 foot bgs.
- The monitoring wells will be developed by surging and pumping across the entire screened interval. The primary purpose of well development is to optimize well efficiency and reduce turbidity.

Monitoring wells will be registered by the drilling subcontractor in accordance with state and local regulations.

SAP Worksheet #14—Summary of Project Tasks (continued)

Environmental Sampling

- Groundwater sample collection
  - Before well purging begins, static groundwater elevations will be measured in all monitoring wells using a water level indicator or oil and water interface probe, as appropriate. The depth from the top of casing to fluid level will be recorded to the nearest 0.01 foot. The indicator will be decontaminated after use in each well.
  - Groundwater samples will be collected using a peristaltic or bladder pump following the low-flow purging and sampling procedures contained in the Groundwater Sampling SOP (**Attachment 2**). The flow rate will be selected as the highest rate within the range of 0.3 liter per minute to 0.5 liter per minute without drawing the water level down by more than 5 percent of the water column. The samples will be analyzed for the analytical groups listed in **Worksheet #20**. Initially, each well will be purged to remove stagnant water by placing the sample tubing or pump intake in the middle of the well screen and pumping until WQPs stabilize. The WQPs, including specific conductance, pH, turbidity, temperature, dissolved oxygen, and ORP, will be measured and recorded (approximately every 5 minutes) during the purging phase using a multi parameter water quality meter, calibrated on a daily basis and as subsequently warranted. Sampling will begin when WQPs have stabilized or three well volumes have been purged. Depth to water, WQPs, and total well depth measurements will be recorded in the field logbook.
  - Sample containers and specifications are listed in **Worksheet #19**. During collection of VOC samples, the bottleware will be filled so as to minimize aeration of the samples and care will be taken such that any preservative is not rinsed from the sampling container. Sample vials will be filled completely and capped to prevent the entrapment of air bubbles in the vial. Groundwater sampling SOPs are provided in **Attachment 2**.
- Pore Water Sampling
  - The location of each proposed sampling location will be loaded into a handheld global positioning system device before the sampling event. The field team will make every effort to collect samples from the pre-determined coordinates; however, sample locations may be adjusted to accommodate site constraints (for example, poison ivy-free area).

SAP Worksheet #14—Summary of Project Tasks (continued)

- The sampling approach will consist of a dual-cased well-point system that incorporates an inner and outer well screen to reduce turbidity. The outer casing will consist of 2-inch inner diameter Schedule 40 PVC piping attached by flush threads to a 1-foot section of 0.010-inch machine-slotted well screen with a pointed end cap. The assembled casing and screen will be carefully driven into the sediment so that the top of the screen is approximately 2 inches below the sediment surface. Once installed, the outer casing will be purged of at least one saturated casing volume using a peristaltic pump with tubing that extends to the bottom of the screened interval.
- The inner casing will consist of a 1-inch inner diameter Schedule 40 PVC casing, attached by flush threads to a 1-foot section of 0.010-inch machine-slotted well screen. A stainless steel mesh will be attached to the exterior of the screened section of casing and filled with a 30/40 mesh sand filter pack. The inner casing and screen will be inserted into the outer casing
- A peristaltic pump will be used to purge the inner casing using low-flow procedures of at least one saturated well volume and will continue until WQPs (specific conductance, pH, total dissolved solids, temperature, and ORP) stabilize. During VOC sample collection, the bottles will be filled so as to minimize aeration of the samples, and care will be taken such that any preservative is not rinsed from the sampling container. Sample vials will be filled completely and capped to prevent the entrapment of any air bubbles in the vial. Pore water sampling SOPs are provided in **Attachment 2**.
- Following completion of the purge, pore water samples will placed in laboratory-supplied containers. Sample containers and specifications are listed in **Worksheet #19**.

Slug Testing

- Rising head tests will be used to assess the aquifer properties at Site 89. The tests will be accomplished by lowering the head of water in the well and, using a datalogger and pressure transducers, monitor the recovery of the water level to the static water level. The water level will be lowered by the use of an air displacement device or alternatively, a water displacement device removed from the well will be used. All slug testing will be conducted in accordance with the Aquifer Slug Testing SOP (**Attachment 2)**.
- The datalogger will be programmed to display the air pressure in units of head, the head measured by the submerged transducer, and the difference between the two. The readings will be recorded in a field notebook.
- If an air displacement device is used, the air pressure applied will be equivalent to 3 to 7 feet of head. The pressures will be allowed to stabilize. The pressure of the air should not lower the water level to below the base of the bentonite seal installed in the well.

SAP Worksheet #14—Summary of Project Tasks (continued)

- Each test will be started by releasing pressure and allowing the water to rise to the static water level. The datalogger will record the water levels and elapsed time. The test will be terminated when the water level has recovered to at least 90 percent of the original equilibrium level before pressurization. Note that the pneumatic test method cannot be used if the well is screened across or near the water table.
- At least two valid tests will be performed in each well. Additional tests will be required if there is some evidence that any of the tests were unacceptable. At the end of each test, the test results will be transferred to a laptop and the data downloaded and checked for preliminary completeness.

Decontamination and Investigation-derived Waste Handling

- Refer to the Decontamination Procedures SOP (**Attachment 2**) for specific implementation guidelines and details.
- All non-disposable sampling equipment will be decontaminated before use and immediately after each use in accordance with applicable SOPs provided in **Attachment 2**.
- Wastes generated during the investigation of potentially contaminated sites are classified as investigation-derived waste (IDW) and will be managed to protect human health and the environment, as well as to meet legal requirements. IDW will be managed in accordance with the Waste Management Plan (CH2M HILL, 2011a). The FTL will be responsible for the supervising the containerization of IDW and its transportation to the appropriate on-Base staging facility. The containers will be handled and labeled in accordance with the Waste Management Plan (CH2M HILL, 2011a). Tubing, gloves, paper towels, and other similar materials will be placed in opaque, black garbage bags and placed into on-Base trash receptacles.

Demobilization

Full demobilization will occur when the project is completed and appropriate QA/QC checks have been performed. Personnel no longer needed during the course of field operations may be demobilized before the final project completion date. The following will occur before demobilization:

- Chain-of-custody records will be reviewed to ensure that all samples were collected as planned and submitted for appropriate analyses.
- The site will be restored to an appropriate level (for example, deep ruts will be repaired) and the restoration will be verified by the CH2M HILL FTL.
- All equipment will be inspected, packaged, and shipped to the appropriate location.

SAP Worksheet #14—Summary of Project Tasks (continued)

Analyses and Testing Tasks

The analytical laboratories will process and prepare samples for analyses and will analyze all samples for various groups of parameters in accordance with this UFP-SAP.

Quality Control Tasks

- Implement SOPs for field and laboratory activities being performed.
- QC samples are described on **Worksheet #20**.

Secondary Data

- Secondary data (**Worksheet #13**) provided by CH2M HILL will be incorporated into subsequent reports, as needed.

Data Validation, Review, and Management Tasks

- Procedures for recording data, including guidelines for recording and correcting data:
  - See the Navy CLEAN Data Management Plan in the Data Management Guidelines in **Attachment 3** of this UFP-SAP.
- Computerized and manual procedures for data generation to final use and storage and QC checks for error detection to ensure data integrity:
  - See the Navy CLEAN Data Management Plan in Data Management Guidelines in **Attachment 3** of this UFP-SAP.
- Guidance on data management steps such as data recording, data transformation, data reduction, data transfer and transmittal, data analysis, and data review
  - See the Navy CLEAN Data Management Plan in Data Management Guidelines in **Attachment 3** of this UFP-SAP.
- Procedures for data tracking, storage, archiving, retrieval, and security for both electronic and hardcopy data:
  - See the Navy CLEAN Data Management Plan for more information (**Attachment 3**)
  - The PDM, Troy Horn, is responsible for data tracking and storage.
  - CH2M HILL will coordinate archiving and retrieval of data.
- Perform data validation via a third-party subcontractor (DataQual) in accordance with **Worksheets #34-36**.

Documentation and Reporting

- Work and data will be documented in the Summary Technical Memorandum.

Assessment/Audit Tasks

- See **Worksheets #31** and **#32**.

SAP Worksheet #15-1—Reference Limits and Evaluation Table

Matrix: Groundwater, Pore Water

Analytical Group: VOCs

Analyte	CAS Number	NCGWQS[1] (µg/L)	Industrial Worker Screening Level[1] (µg/L)	North Carolina Administrative Code 2B Human Health[1] (µg/L)	Project Quantitation Limit (QL) Goal[2] (µg/L)	Laboratory-Specific (µg/L)			Laboratory Control Sample (LCS), matrix Spike (MS), and MSD Percent Recovery (%R) Limits[3]	
						LOQ	LOD	DL	LCL	UCL
VC	75-01-4	0.03	31.9	2.4	0.015	1.0	1.0	0.71	50	145
trans-1,2-DCE	156-60-5	100	NC	NC	50	1.0	1.0	0.72	60	140
cis-1,2-DCE	156-59-2	70	NC	NC	35	1.0	1.0	0.49	70	125
TCE	79-01-6	3	587.0	30	1.5	1.0	1.0	0.55	70	125
1,1,2-TCA	79-00-5	5 [4]	NC	NC	0	1.0	1.0	0.63	75	125
PCE	127-18-4	0.7	24.0	3.3	0.35	1.0	1.0	0.76	45	150
1,1,2,2- PCA	79-34-5	0.2	31.0	4	0.1	1.0	1.0	0.54	65	130

CAS = Chemical Abstract Service; DL = detection limit; LCL – lower confidence limit; LOD = limit of detection; LOQ = limit of quantitation; UCL = upper confidence limit

[1] PALs were developed to be protective of human health and the environment. Refer to **Worksheet #11** for a detailed discussion on the development of PALs.

[2] Project QL goals are equal to half of the minimum of the applicable criteria (PALs).

[3] U.S. Department of Defense (DoD) Quality Systems Manual (QSM) v.4.1 is the basis for LCS and MS/MSD limits.

[4] No NCGWQS exists for 1,1,2-TCA; the MCL is shown.
NC indicates that there is no criterion for a particular analyte.

Shading represents cases where the NCGWQS is lower than the laboratory LOD. If that specific constituent is nondetect, the analyte will be considered not present. The NCGWQS is used for comparative purposes only; the PAL is the industrial worker screening level.

SAP Worksheet #15-2—Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Dissolved gases (NAIPs)

Analyte	CAS Number	Project Indicator Limit (PIL) Goal[1] (µg/L)	Project QL Goal[2] (µg/L)	Laboratory-Specific (µg/L)			LCS, MS, and MSD %R and % Relative Percent Difference (RPD) Limits[3]		
				LOQ	LOD	DL	LCL	UCL	RPD
Methane	74-82-8	> 500	Lab LOD	1	0.956	0.72	**74**	**116**	**18**
Ethane	74-84-0	> 100	Lab LOD	2	1.79	1	**72**	**131**	**12**
Ethene	74-85-1	> 100	Lab LOD	3	1.66	2.3	**75**	**123**	**14**

[1] PILs were developed to assist in determining if evidence exists for natural attenuation processes.

- Methane results are used to determine the oxidation of an aquifer. Once most or all oxygen is consumed, methanogenic microorganisms can thrive and methane is produced. Detections of methane are generally consistent with an Eh of less than -100 millivolts.
- Ethane and ethene results are used to determine how much degradation of chlorinated ethenes has occurred in groundwater at a site. Typically, the presence of these compounds indicates complete degradation of PCE, TCE, or DCE.

[2] Project QL goals are equal to the laboratory LOD.

[3] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits. Bolded values represent in-house limits when DoD QSM v.4.1 limits do not exist.

SAP Worksheet #15-3—Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Metals (NAIPs)

Analyte	CAS Number	PIL Goal[1] (µg/L)	Project QL Goal[2] (µg/L)	Laboratory-Specific (µg/L)			LCS and MS/ MSD %R Limits[3]	
				LOQ	LOD	DL	LCL	UCL
Iron	7439-89-6	>1,000	Lab LOD	50	15	3.8	**80**	**120**
Manganese	7439-96-5	NC	Lab LOD	10	0.800	0.200	**80**	**120**

[1] PILs were developed to assist in determining if evidence exists for natural attenuation processes. Iron present at concentrations greater than 1 mg/L and the presence of manganese indicates that reductive dechlorination is a potential pathway for Chlorinated VOC degradation.

[2] Project QL goals are equal the laboratory LOD.

[3] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits: values are bolded to indicate in-house limits are used.

NC indicates that there is no criterion for the particular analyte.

SAP Worksheet #15-4—Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Wet Chemistry (NAIPs)

Analyte	CAS Number	PIL Goal[1] (µg/L)	Project QL Goal[2] (µg/L)	Laboratory-Specific (µg/L)			LCS and MS/ MSD %R Limits[3]	
				LOQ	LOD	DL	LCL	UCL
Chloride	16887-00-6	NC	Lab LOD	5000	1200	290	**90**	**110**
Sulfate	14808-79-8	<20,000	Lab LOD	5000	260	70	**90**	**110**
Sulfide	18496-25-8	>1,000	Lab LOD	1000	1000	450	**84**	**106**
Alkalinity	471-34-1	>50,000	Lab LOD	2000	2000	2000	**90**	**110**
TOC	TOC	>20,000	Lab LOD	1000	900	270	**85**	**115**

[1] PILs were developed to assist in determining if evidence exists for natural attenuation processes.

- Chloride results are used to determine the level of degradation of chlorinated compounds in groundwater.
- Sulfate and sulfide results are also used to help determine the oxidation state of an aquifer. Typically, once iron has been reduced, sulfate is reduced to sulfide. The presence or sulfide or absence (or low levels of sulfate), typically indicate an Eh of approximately 0 to -300 millivolts.
- Alkalinity is a measure of the buffering capacity of an aquifer. It gives us an idea of how resistant an aquifer will be to attempts to change pH. This is important when evaluating the potential for implementation of treatment technologies that may be pH-sensitive (such as chemical oxidation) or are likely to change pH (such as the addition of some organic substrates).
- TOC results will be used to determine the bioavailability of organic chemicals.

[2] Project QL goals are equal the laboratory LOD.

[3] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits. Bolded values represent in-house limits when DoD QSM v.4.1 specified limits do not exist.

NC indicates that there is no criterion for a particular analyte.

SAP Worksheet #15-5—Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Microbials

Analyte[1]	CAS Number[2]	Laboratory-Specific (gene copies/milliliter [mL])	
		LOQ	DL
Dehalococcoides (DHC)	DHC	0.5	0.10
BAV1 R-Dase	BAV1-R	0.5	0.10
TCE R-Dase	TCE-R	0.5	0.10
VC R-Dase	VC-R	0.5	0.10

[1] The presence of DHC and the three functional genes listed in-table will assist in determining if evidence exists for natural attenuation processes.
[2] This value is a contractor-specific identifier.

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SAP Worksheet #16—Project Schedule / Timeline Table

Activities	Organization	Dates (MM/DD/YY)		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
Work Plan preparation	CH2M HILL	7/25/11	9/23/11	Draft UFP-SAP	9/23/11
Work Plan reviewed by Navy	Navy	9/26/11	10/7/11	Comments	10/7/11
Work Plan – address Navy comments	CH2M HILL	10/10/11	10/14/11	Draft UFP-SAP	10/14/11
Work plan review and approval by regulatory agencies	NCDENR, EPA Region IV	10/17/11	10/28/11	Draft UFP-SAP	10/28/11
Final acceptance	Navy, NCDENR, EPA Region IV	10/31/11	11/7/11	Final UFP-SAP	11/7/11
Subcontracting	CH2M HILL	7/25/11	9/16/11	Subcontractor Contracts	9/16/11
Field sampling activities	Subcontractor w/ CH2M HILL	11/7/11	12/9/12	Environ. Samples	12/9/11
Laboratory analyses and data validation	CH2M HILL	12/5/11	1/11/12	Analytical and Data Validation Reports	1/11/12
Data management and report preparation	CH2M HILL	12/5/11	3/2/12	Draft FS Addendum Tech Memo	3/2/12
Tech Memo reviewed by Navy	Navy	3/5/12	3/16/12	Comments on the Tech Memo	3/16/12
Tech Memo – Address comments	CH2M HILL	3/19/12	3/23/12	Response to Comments	3/23/12
Tech Memo review and approval by regulatory agencies	NCDENR, EPA Region IV	3/26/12	4/20/12	Comments on the Tech Memo	4/20/12
Incorporate comments and finalize Tech Memo	CH2M HILL	4/23/12	4/27/12	Final FS Addendum Tech Memo	4/30/12

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SAP Worksheet #17—Sampling Design and Rationale

General Approach

The general approach for this investigation was developed to meet Navy, EPA, and NCDENR requirements for the investigation of environmental media that may have been impacted by past waste management practices. The primary objective of this investigation is to further refine the nature and extent of contamination at the site for the remedial design.

The sampling design was designed to assess the vertical distribution of COCs in groundwater by sampling existing and newly installed wells in the former DRMO area. Pore water sample locations were chosen downgradient of suspected source areas to determine to what extent impacted groundwater may be discharging into Edwards Creek.

Sample Matrices

Sample matrixes will include groundwater and pore water.

Analytical Groups

For groundwater, the target analytical group will be select VOCs, NAIPs, and microbials, as listed in **Worksheet #15**.

For pore water, the target analytical group will be select VOCs.

VOCs were selected as the target analytes for groundwater and pore water samples based on previous site investigations. The rationale for the selection of NAIPs was to assess whether the conditions within the target aquifer zones are suitable for reductive dechlorination in the groundwater. The rationale for microbial analysis was to assess whether microbial levels are favorable for biodegradation at the site.

Site Sample Numbers and Locations

For Site 89, the sampling approach, rationale for the matrixes to be sampled, number of samples per matrix, analytical groups, and the relevant concentration action levels are discussed in **Worksheets #10, #11, #14, and #15**. A sample location figure is provided in **Worksheet #10 (Figure 10-3)**. Exact sampling locations will be selected in the field by CH2M HILL personnel and may be re-located to avoid site obstructions, if present. Site sampling locations were agreed upon by the Partnering Team.

The sampling design was developed to refine the horizontal and vertical distribution of COCs in groundwater in the DRMO area and to determine to what extent groundwater is discharging into Edwards Creek.

Sampling Frequency and Seasonal Considerations

The field team will collect one set of environmental samples from Site 89. Sampling is scheduled to occur during the fourth quarter of 2011. One round is sufficient for making determinations for the remedial design.

SAP Worksheet #17—Sampling Design and Rationale (continued)

Site 89

Matrix	Depth of Samples	Analysis	Method	Number of Samples	Rationale	Sampling Strategy
Groundwater	Middle of well screen	Select VOCs	SW-846 EPA Method 8260B	20	Evaluate the nature and extent of VOC impacts to groundwater. Sample locations were selected based on previously detected VOC concentrations in groundwater.	See **Figure 10-3** for proposed sampling locations.
		Methane, Ethane, Ethene	RSK-175	20		
		Iron, Manganese	SW-846 6010C	20		
		Chloride, Sulfate	EPA 300.0	20		
		Sulfide	SM4500-S2-F	20		
		Alkalinity	SM2320B	20		
		TOC	SW846 9060A	20		
		DHC and functional genes: TCE Reductase, VC reductase, and BAV1 reductase	Quantitative polymerase chain reaction (qPCR)	4		
Pore Water	greater than 6 inches below water/sediment interface	Select VOCs	SW-846 EPA Method 8260B	10	Evaluate where VOC-impacted groundwater is discharging into Edwards Creek.	See **Figure 10-3** for proposed sampling locations.

SAP Worksheet #18—Sampling Locations and Methods/SOP Requirements Table

Location[1] (Station ID)	Matrix	Analytical Group	Number of Samples	Sample ID	Sampling SOP Reference
Site 89					
IR89-MW79IW IR89-MW79DW IR89-MW80IW IR89-MW81IW IR89-MW81DW IR89-MW82IW IR89-MW82DW IR89-MW11IW* IR89-MW16IW* IR89-MW57* IR89-MW09IW* IR89-MW02IW* IR89-MW03IW* IR89-MW03DW* IR89-MW52IW IR89-MW52DW	Groundwater	Select VOCs, NAIPs	16	IR89-GW79IW-11C IR89-GW79DW-11C IR89-GW80IW-11C IR89-GW81IW-11C IR89-GW81DW-11C IR89-GW82IW-11C IR89-GW82DW-11C IR89-GW11IW-11C IR89-GW16IW-11C IR89-GW57-11C IR89-GW09IW-11C IR89-GW02IW-11C IR89-GW03IW-11C IR89-GW03DW-11C IR89-GW52IW-11C IR89-GW52DW-11C	See **Worksheet #21**
IR89-MW53IW IR89-MW53DW IR89-MW17IW* IR89-MW80DW	Groundwater	Select VOCs, NAIPs, and microbial	4	IR89-GW53IW-11C IR89-GW53DW-11C IR89-MW17IW-11C IR89-GW80DW-11C	
IR89-WN01 through IR89-WN10	Pore Water	Select VOCs	10	IR89-WN01-11B Through IR89-WN10-11B	
Site89-QC	QC	Select VOCs		IR89-EB##-MMDDYYYY IR89-TB##-MMDDYYYY IR89-FB##-MMDDYYYY	

[1]Refer to **Figure 10-3** for sample locations

*Denotes existing well

ID - identification

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SAP Worksheet #19—Analytical SOP Requirements Table

Matrix[1]	Analytical Group	Analytical and Preparation Method/ SOP Reference[2]	Containers (Number, Size, and Type)	Minimum Sample Amount	Preservation Requirements (Chemical, Temperature, Light Protected)	Maximum Holding Time (Preparation/ Analysis)[3]
Groundwater, Pore Water, and/or Aqueous Blanks	VOCs	SW-846 8260B/5030B/VGCMS-05	3, 40 mL Vials, Glass	3 X 40 mL (no headspace)	HCl to pH<2, Store cool at <6°C	14 days
	Methane, Ethane, Ethene	RSK-175/VGC-11	3, 40 mL Vials, Glass	3 X 40 mL (no headspace)	Store cool at < 6ºC	14 days
	Iron and Manganese	SW-846 6020A/3005A/MET-15	1, 250 mL Plastic	100 mL	HNO3 to pH<2, store cool at < 6ºC	180 days
	Chloride and Sulfate	SW-846 9056A/WETS-057	1, 250 mL Plastic	130 mL	Store cool at 6ºC	28 days
	Sulfide	SM 18 4500-S-E/WETS-061	1, 250 mL, Plastic	250 mL	ZnAc+NaOH, store cool at < 6º	7 days
	Alkalinity	EPA 310.2/WETS-047	1, 250 mL, Plastic	100 mL	Store cool at < 6ºC	14 days
	TOC	SW 846 9060A/WETS-066	3, 40 mL Amber, Glass	3 X 40 mL (no headspace)	H3PO4 to pH<2, store cool at < 6º C	28 days
	Microbials	qPCR and ribonucleic acid (RNA) extraction/MI SOP RNA-EXT and MI SOP-qPCR	2 bio-flo filters, 1000 mL passed through each	2 bio-flo filters, volume passed through filter varies with turbidity of sample	3 mL preservative per bio-flo filter, store cool at < 6º C	24-48 hours

[1] Refer to **Worksheet #18** for specifics of which samples will be analyzed for which analytical groups.

[2] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

[3] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

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SAP Worksheet #20—Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs	No. of Equip. Blanks*	No. of Volatile Organic Analyte (VOA) Trip Blanks*	Total No. of Samples to Lab
Groundwater	VOCs	20	2	1/1	5	2	31
	NAIPs	20	-	-	-	-	20
	Microbials	4	-	-	-	-	4
Pore Water	VOCs	10	1	1/1	1	1	15

*Blank count is approximated based on estimated field activity duration; refer to **Worksheet #12** for field QA/QC sampling frequency.

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SAP Worksheet #21—Project Sampling SOP References Table

Reference Number	Title, Revision Number and/or Date	Originating Organization	Equipment Type	Modified for Project Work?	Comments
SOP-001	*Completing Log Books*, rev. 5/2011	CH2M HILL	Log book indelible pen	No	
SOP-002	*Locating and Clearing Underground Utilities,* rev. 5/2011		Electromagnetic inductance		
SOP-003	*Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a multi parameter water quality meter with Flow through Cell,* rev. 05/2011		Water quality meter with flow-though cell		
SOP-004	*Low-Flow Groundwater Sampling from Monitoring Wells*, rev. 05/2011		Peristaltic pump or bladder pump, plastic tubing		Include purging a minimum of one well volume per NCDENR
SOP-005	*Decontamination of Personnel and Equipment,* rev. 05/2011		Reusable sampling equipment		
SOP-0006	*Decontamination of Drilling Rigs and Equipment*, rev. 05/2011		Steam cleaner and decontamination pad		
SOP-007	*Disposal of Waste Solids and Fluids,* rev. 05/2011		55-gallon drum with on-Base staging		
SOP-008	*Equipment Blank and Field Blank Preparation*, rev. 05/2011		Lab-provided blank liquid and sample bottles		
SOP-009	*Packaging and Shipping Procedures for Low-Concentration Samples*, rev. 03/2010		Lab-supplied coolers		
SOP-010	*Chain-of-Custody,* rev. 05/2011		Chain-of-Custody Form		
SOP-011	*MultiRAE Photoionization Detector* (PID), rev. 05/2011		PID		

SAP Worksheet #21—Project Sampling SOP References Table (continued)

Reference Number	Title, Revision Number and/or Date	Originating Organization	Equipment Type	Modified for Project Work?	Comments
SOP-012	*Monitoring Well Installation using Sonic Drilling*, rev. 05/2011	CH2M HILL	Well construction materials, development equipment	No	
SOP-013	*Water-Level Measurements*, rev. 05/2011		Electronic water-level meter		
SOP-014	*VOC Sampling- Water*, rev. 05/2011		Sample vials pre-preserved at lab with HCl		
SOP-015	*Aquifer Slug Testing,* rev. 05/2011		Datalogger, well testing assembly		
SOP-016	*Logging of Soil Borings*, rev. 05/2011		Soil-color, grain size, and Unified Soil Classification System index chart		

SAP Worksheet #22—Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Activity[1]	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference[2]	Comments
Peristaltic Pump/ Submersible Pump/ Bladder pump	Maintenance	As Needed, Regularly	Specific per model/instruction manual	Rental and/or manufacturer support for pump malfunctions	FTL	SOP-004	
Multi-RAE/ Mini-RAE PID	Calibrate sensor	Daily, As Needed	Parameter specific per model/ instruction Manual	Manufacturer technical support for calibration errors	FTL	SOP-011	
Water quality meter	Calibrate probes	Daily, As Needed	Parameter specific per model/instruction manual	Manufacturer technical support for calibration errors	FTL	SOP-003	

1 Activities may include calibration, testing, and maintenance.

2 See **Worksheet #21**.

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SAP Worksheet #23—Analytical SOP References Table

Lab SOP Number	Title, Revision Date and/or Number	Last Reviewed	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM	Modified for Project Work (Y/N)
LOGINS-03	RECEIVING SAMPLES (Rev. 10, Effective 1/23/2010)	4/20/2011	NA	NA	NA	ENCO - Orlando	None	N
ADMIN-14	WASTE DISPOSAL AND CHARACTERIZATION (Rev. 5, 12/1/2009)	1/4/2011	NA	NA	NA	ENCO - Orlando/ ENCO-Jacksonville	None	N
VGC-11	Analysis of Dissolved Gases by Headspace GC/TCD/FID (Rev. 5, Effective 06/24/2011)	6/24/2011	Screening	Aqueous RSK-175	GC/FID	ENCO-Jacksonville	None	N
VGCMS-05	Analysis of VOCs by GC-MS (Rev.16, Effective 11/29/2010)	11/29/2010	Definitive	Soil, Aqueous VOC	GC/MS	ENCO - Orlando	None	N
EXMT-12	Acid Digestion of Aqueous Samples for Analysis by ICP and ICP-MS (Rev. 4, 11/30/2009)	11/30/2010	NA	Aqueous Metals Prep	NA	ENCO - Orlando	None	N
MET-15	Metals Analysis using ICP-MS (Rev. 5, Effective 2/14/2011)	2/14/2011	Screening	Aqueous Metals	ICP/MS	ENCO - Orlando	ENCO does not perform Method of Standard Additions	N
WETS-047	Alkalinity (Methyl Orange, Automated),(Rev. 2, Effective 6/21/2011)	06/21/2011	Screening	Aqueous Alkalinity	Lachet	ENCO - Orlando	None	N
WETS-057	Ion Chromatography (IC) (Rev. 5, Effective 1/28/2010)	4/8/2011	Screening	Aqueous Ions	IC	ENCO - Orlando	None	N
WETS-061	Sulfide (Titrimetric Iodine) (Rev. 4 Effective 6/21/2009)	3/11/2011	Screening	Aqueous Sulfide	NA	ENCO - Orlando	None	N

SAP Worksheet #23—Analytical SOP References Table (continued)

Lab SOP Number	Title, Revision Date and/or Number	Last Reviewed	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to QSM	Modified for Project Work (Y/N)
WETS-066	TOC, Method 415.1, SW 846 9060 (Rev. 4, Effective 1/23/2010)	04/20/2011	Screening	Aqueous TOC	TOC Combustion Analyzer	ENCO - Orlando	None	N
MI SOP qPCR	Quantitative Polymerase Chain Reaction (qPCR), 1/10/06, Rev 1.0	6/17/2011	Screening	Aqueous Microbials	qPCR	Microbial Insights	None	N
MI SOP RNA-EXT	Extraction of RNA from Environmental Samples (Matrix- Water, Soil, Biofilm, Bio-Sep Beads), 1/5/06, Rev 1.0	6/17/2011	NA	Aqueous Microbials prep	NA	Microbial Insights	None	N

FID = flame ionization detector; GC = gas chromatograph; ICP = inductively coupled plasma; MS = mass spectrometer; TCD = thermal conductivity detector

SAP Worksheet #24-1—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference[1]
GC-MS (VOA)	Tuning	Prior to initial calibration (ICAL) and at the beginning of each 12-hour period.	Refer to method for specific ion criteria.	Retune instrument and verify. Rerun affected samples.	Analyst	VGCMS-05
	Minimum five-point ICAL for all analytes	ICAL prior to sample analysis.	1. Average response factor (RF) for system performance check compounds: VOCs ≥0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; VOCs ≥0.1 for chloromethane, bromoform, and 1,1-dichloroethane. 2. Relative standard deviation (RSD) for RFs for CCCs: VOCs ≤ 30% and one option below: Option 1: RSD for each analyte ≤ 15%; Option 2: linear least squares regression r ≥ 0.995; Option 3: non-linear regression-coefficient of determination (COD) r2 ≥ 0.990 (6 points shall be used for second order, 7 points will be used for third order).	Correct problem then repeat ICAL.		
	Second source calibration verification	Once after each ICAL.	All project analytes within ± 20% of true value.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	Retention time window position establishment for each analyte and surrogate.	Once per ICAL.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial continuing calibration verification (CCV) is used.	NA.		
	Evaluation of relative retention time (RRT)	With each sample.	RRT of each target analyte within ± 0.06 RRT units.	Correct problem, then rerun ICAL.		
	CCV	Daily before sample analysis and every 12 hours of analysis time.	1. Average RF for system performance check compounds: VOCs≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachlorolethane; ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethane. 2. %Difference/Drift for all target compounds and surrogates: VOCs ≤ 20%D (Note: D = difference when using RFs or drift when using least squares regression or non-linear calibration).	DoD project level approval must be obtained for each of the failed analytes or CA must be taken. Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since last acceptable CCV.		

SAP Worksheet #24-2—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference[1]
GC/FID	ICAL for all analytes	Daily ICAL prior to sample analysis.	Calculate RF for each standard, compute average RF and percent RSD. RSD <20%. Optionally, a linear regression curve may be fit if the correlation coefficient > 0.990.	Correct problem then repeat ICAL.	Analyst	VGC-11
	Second source calibration verification	Once after each ICAL.	All project analytes within ± 25% of true value.	Verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	CCV	Before any samples in sequences that don't include ICALs, after every 24 hours, and at the end of the sequence.	All project analytes within ± 20% of true value.	Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.		

[1] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

SAP Worksheet #24-3—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference[1]
ICP-MS	Tuning	Prior to ICAL.	Mass calibration≤ 0.1atomic mass unit (amu) from the true value; Resolution < 0.9 amu full width at 10% peak height; For stability, RSD≤ 5% for at least four replicate analyses.	Retune instrument then reanalyze tuning solutions.	Analyst	MET-15
	ICAL for all analytes (minimum 2 point calibration, plus calibration blank)	Daily ICAL prior to sample analysis.	More than one calibration standard is used, R≥ 0.995.	Correct problem, then repeat ICAL.		
	Second source calibration verification	Once after each ICAL, prior to beginning a sample run.	Value of second source for all analytes within ± 10% of true value.	Verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	CCV	After every 10 field samples and at the end of the analysis sequence.	All analytes within ± 10% of true value.	Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.		
	Calibration blank	Before beginning a sample run, after every 10 samples, and at end of the analysis sequence.	No analytes detected > LOD.	Correct problem. Re-prep and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.		
	Interference check solutions (ICS-A and ICS-AB)	At the beginning of an analytical run and every 12 hours.	ICS-A: Absolute value of concentration for all non-spiked analytes < LOD (unless they are a verified trace impurity from one of the spiked analytes); ICS-AB: Within ± 20% of true value.	Terminate analysis, locate and correct problem, reanalyze ICS, reanalyze all samples.		

SAP Worksheet #24-4—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference[1]
IC (Chloride, Sulfate)	ICAL, minimum of three standards and a calibration blank	Every 6 months, ICAL prior to sample analysis.	COD at least 0.995	Correct problem then repeat ICAL.	Analyst	WETS-57
	Second source calibration verification	Once after each ICAL.	All analytes within ± 10% of true value and retention times within appropriate windows	Verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	CCV	After every 10 field samples and at the end of the analysis sequence.	All project analytes within established retention time windows. Within ± 10% of true value.	Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.		
	Retention Time Windows	One per multipoint calibration for each analyte.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA		

[1] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

SAP Worksheet #24-5—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference[1]
Lachat	ICAL, minimum of six standards and a calibration blank	Daily ICAL prior to sample analysis.	COD at least 0.995	Correct problem then repeat ICAL.	Analyst	WET-47
	Second source calibration verification	Once after each ICAL.	All analytes within ± 10% of true value and retention times within appropriate windows	Verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	CCV	After every 10 field samples and at the end of the analysis sequence.	All analytes within ± 10% of true value.	Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.		

[1] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

SAP Worksheet #24-6—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference[1]
TOC Analyzer	ICAL, minimum of five standards and a calibration blank	Annually, ICAL prior to sample analysis.	COD at least 0.995.	Correct problem then repeat ICAL.	Analyst	WETS-066
	Second source calibration verification	Once after each ICAL.	All analytes within ± 15% of true value and retention times within appropriate windows.	Verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.		
	CCV	After every 10 field samples and at the end of the analysis sequence.	All analytes within ± 15% of true value.	Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.		

[1] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

SAP Worksheet #24-7—Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	CA	Person Responsible for CA	SOP Reference[1]
ABI 7300	Initial	Primary – annual	Standard curve R^2 >0.95	Rerun assay / check reagents.	Analyst	MI SOP-qPCR
	CCV	Secondary – every plate (assay)	CT value within 2 units of same point on standard curve	Rerun assay / check reagents.		

[1] Refer to **Worksheet #23** for a complete reference to relevant analytical SOPs.

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SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	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	VGCMS-05
	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, re-analyze CCV, and re-calibrate instrument.		
GC/FID	Injection port maintenance	NA	Evaluate baseline and peak shapes	As needed	Analyst judgment of excessive tailing or baseline fluctuation.	Clip the guard column, replace the injection port liner, replace the gold seal, clean the injection port, and replace the injection port septum.	Analyst	VGC-11
ICP-MS	Clean, inspect, change cones.	Monitor internal standards (IS) counts for variation	Instrument performance and sensitivity.	As needed.	Monitor IS counts for variation.	Re-calibrate.	Analyst	MET-15
	Clean, inspect, change spray chamber, injector, torch.	Monitor IS counts for variation	Instrument performance and sensitivity.	As needed.	Monitor IS counts for variation.	Re-calibrate.		

SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table (continued)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference
	Replace pump windings.	Monitor IS counts for variation	Instrument performance and sensitivity.	As needed.	Monitor IS counts for variation.	Replace windings, re-calibrate and re-analyze.		
IC	Fill eluent bottles and fill reservoir water bottle.	NA	Visual	Weekly or as needed	NA	Fill bottle as needed.	Analyst	WETS-057
	Check back pressure is below 2300 PSI.	NA	Visual	Weekly or as needed	NA	Clean or replace guard column and frit.		
	Check IC for leaks.	NA	Visual check for liquid or pressure fluctuation.	Weekly or as needed	NA	Fix leak.		
Lachat	Oil Pump Rollers.	NA	Back flow observed.	Every 2 weeks	CCV pass criteria	Oil as needed.	Analyst	WETS-047
	Replace sample line and water reservoir line.	NA	Back flow observed.	Every 2 weeks	CCV pass criteria	Change as needed or look for line clogs.		
	Replace reagent lines.	NA	Back flow observed.	Monthly	CCV pass criteria	Change as needed or look for line clogs.		
	Replace valve o-ring.	NA	Back flow observed.	Monthly	CCV pass criteria	Change as needed or look for line clogs.		
TOC Analyzer	Inspect and/or clean TOC syringe.	NA	Visual	Monthly	NA	Clean as needed.	Analyst	WETS-066
	Inspect Permeation Dryer.	NA	Visual	Monthly	NA	Replace if humidity observed.		

SAP Worksheet #25—Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table (continued)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person	SOP Reference
	Test fittings on 8-port valve.	NA	Visual check for leaks.	Monthly	NA	Replace or tighten fittings as needed.		
	Replace Injection Line.	NA	Peak shape and uniformity between injection replicates.	As needed	CCV pass criteria	Replace line.		
	Replace corrosive scrubber (tin and copper).	NA	Visual check for discoloration.	As needed	CCV pass criteria	Replace tin and copper.		
	Replace/wash and condition catalyst and combustion tube.	NA	CCV passing.	As needed	CCV pass criteria	Replace and condition.		
ABI 7300 (DHC)	Background check monthly; Dye calibration annually	ICAL Verification and Background check	Monitor instrument performance via ICAL Verification and Blank	Daily, after every 10 samples	Standard curve r^2 value >0.95: CT value within 2 units of same point on standard curve	Clean wells, rerun background assay. See SOP	Analyst	MI SOP qPCR

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SAP Worksheet #26—Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Field Team/CH2M HILL
Sample Packaging (Personnel/Organization): FTL/CH2M HILL
Coordination of Shipment (Personnel/Organization): FTL/CH2M HILL
Type of Shipment/Carrier: Overnight Carrier/ FedEx
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Logins/ENCO Labs, Microbial Insights
Sample Custody and Storage (Personnel/Organization): Logins/ENCO Labs, Microbial Insights
Sample Preparation (Personnel/Organization): Inorganic Prep and Organic Prep/ENCO Labs
Sample Determinative Analysis (Personnel/Organization): Metals, VOA, Wet chemistry analysts/ENCO Labs
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): 45
Sample Extract/Digestate Storage (No. of days from extraction/digestion): 45
Biological Sample Storage (No. of days from sample collection): 45 days if sample remains
SAMPLE DISPOSAL
Personnel/Organization: Kurt Bentzen/ENCO Labs, Sample Custody Personnel/Microbial Insights
Number of Days from Analysis: 45

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SAP Worksheet #27—Sample Custody Requirements

Sample Labeling Procedures

Sample labels will include, at a minimum, client name, site, sample ID, date/time collected, preservative, analysis group or method, and sampler's initials. Each sample will be designated by an alphanumeric code that will identify the facility, site, station ID, matrix sampled, and/or date and depth sampled. QA/QC samples will have a unique sample designation. Nomenclature for samples and field QA/QC is specified in **Worksheet #18**. The field logbook will identify the sample ID with the location, depth, date/time collected, and the parameters requested.

Field Sample Custody Procedures (Sample Collection, Packaging, Shipment, and Delivery to Laboratory)

Field samples will be collected by the field team members under the supervision of the FTL. As samples are collected, they will immediately be placed in the appropriate containers and labeled, as previously outlined. The labels will be filled out in the field by the field crew at the time of sample collection and checked before being placed into the cooler, at which time the sample will be logged in on the chain-of-custody form and field logbook. The integrity of the sample labels will be maintained through the practice of placing sample containers in watertight, resealable plastic bags.

Sample containers will be cushioned with packaging material and placed into coolers containing enough ice to keep the samples below 6 °C until they are received by the laboratory. The chain-of-custody form will also be placed into the cooler. Coolers will be shipped to the laboratory via FedEx, with the airbill number indicated on the chain-of-custody form (to relinquish custody). The FTL is responsible for the care and custody of samples until they are shipped or otherwise delivered to the laboratory custodian, as described in Section 4.3 of the Master Project Plans (CH2M HILL, 2008a). Upon delivery, the laboratory will log in each cooler and report the status of the samples as discussed in the following sections.

Chain-of-custody Procedures

Chain-of-custody forms will include, at a minimum, laboratory contact information, client contact information, sample information, and relinquished by/received by information. Sample information will include sample ID, date/time collected, number and type of containers, preservative information, analysis method, and comments. The chain-of-custody form will also have the sampler's name and signature. The chain-of-custody will link location of the sample from the field logbook to the laboratory receipt of the sample. The laboratory will use the sample information to populate the laboratory information management system database for each sample.

Laboratory Sample Custody Procedures (Receipt of Samples, Archiving, Disposal)

The laboratory receiving samples will comply with all sample custody requirements outlined in the laboratory SOPs referenced in **Worksheet #23**.

SAP Worksheet #27—Sample Custody Requirements Table (continued)

All samples from Site 89 except those for microbial analysis will be shipped to ENCO-Orlando. Microbial samples will be shipped to Microbial Insights. ENCO-Orlando will ship necessary samples to its Jacksonville location.

Sample Integrity

A sample tracking system will be followed to ensure sample authenticity and data defensibility. The Project Chemist will notify the laboratory of upcoming field sampling activities and the subsequent transfer of samples to the laboratory. The PDM will ensure that samples arrive to the lab in the appropriate timeframe and that the condition of samples upon receipt is satisfactory. If samples are not delivered to the lab in the acceptable timeframe or condition, the PM will be notified and the decision will be made whether to recollect samples.

The PDM is responsible for checking the chain-of-custody forms against the field logbook and field project instructions to verify the sample ID, times, analyses, and methods are correct on the forms. Any discrepancies will be resolved with the field team and relayed to the lab. These actions will be documented by both the lab and the PDM. The lab is responsible for providing the PDM with sample login sheets the day of sample receipt in order for the PDM to verify that the lab has accounted for all samples shipped and has correctly logged the samples into its software system.

SAP Worksheet #28-1—Laboratory QC Samples Table

Matrix: Groundwater, Pore Water

Analytical Group: VOA

Analytical Method/SOP Reference: SW-846 8260B / VGCMS-05

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method blank	One per preparatory batch	No target analytes > 1/2 LOQ; no common laboratory contaminants > LOQ.	Correct problem. If required, re-prep and re-analyze method blank and all samples processed with the contaminated blank.	Analyst	Bias/Contamination	Same as QC Acceptance Limits.
LCS		Refer to **Worksheet #15**	LCS is reanalyzed. If still fails, samples along with QC, are re-prepped and re-analyzed. Client will be contacted for guidance about whether to re-prep samples. In the absence of client- specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
MS		Same as LCS.	In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
MSD		Same as LCS and RPD ≤30%.	In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
IS	Spiked in Every Sample	Retention time within 30 seconds from retention time of the midpoint standard in the ICAL; areas within -50% to +100% of ICAL midpoint standard.	Inspect MS and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.		Precision and Accuracy	Same as QC Acceptance Limits.
Surrogates		Dibromofluoromethane 85-115%, Toluene-d_8 85-120%, 1,2-Dichloroethane-d4 70-120%, 4-Bromofluorobenzene 75-120%	Re-prep and re-analyze sample unless objective evidence of suspected or confirmed sample matrix effects are available. If insufficient sample exists for reanalysis, client will be contacted for instructions. In the absence of client instruction, data will be qualified.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.

SAP Worksheet #28-2—Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Dissolved Gases (NAIPs)

Analytical Method/SOP Reference: RSK-175 / VGC-11

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per preparatory batch	No target analytes > 1/2 LOQ; no common laboratory contaminants > LOQ	Correct problem; then repeat. If the method blank still fails; repeat ICAL.	Analyst	Bias/ contamination	Same as QC Acceptance Limits.
LCS		Refer to **Worksheet #15.**	LCS is reanalyzed. If still fails, samples, along with QC, are re-prepped and reanalyzed. Client will be contacted for guidance about whether to re-prep samples. In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD		Same as LCS, refer to **Worksheet #15** for RPD per analyte.	In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.

SAP Worksheet #28-3—Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Metals (NAIPs)

Analytical Method/SOP Reference: SW-846 6020A / MET-15

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per preparatory batch.	No target analytes > 1/2 LOQ.	Correct problem; then repeat. If the method blank still fails; redigest and analyze all affected samples.	Analyst	Bias/Contamination	Same as SOP QC Acceptance Limits.
LCS		See **Worksheet #15**.	LCS is re-analyzed. If still fails, samples, along with QC, are re-prepped and re-analyzed. Client will be contacted for guidance about whether to re-prep samples. In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as SOP QC Acceptance Limits.
MS		Same as LCS.	Perform a dilution test and/or post spike to evaluate matrix effects.		Precision and Accuracy/Bias	Same as SOP QC Acceptance Limits.
MSD		Same as LCS and RPD ≤ 20%.	Perform a dilution test and/or post spike to evaluate matrix effects.		Precision and Accuracy/Bias	Same as SOP QC Acceptance Limits.
Dilution Test	One per preparatory batch containing samples with concentrations >50 x LOQ.	Recovery within ±10% of true value.	Perform post spike.		Precision and Accuracy/Bias	Same as SOP QC Acceptance Limits.
Post Spike	When dilution test fails or analyte concentration for all samples < 50x LOD.	Recovery within ±25% of true value.	If dilution test recovers outside of QC acceptance limits but post spike meets QC acceptance criteria , matrix effects are not confirmed, Reprep and reanalyze sample.		Precision and Accuracy/Bias	Same as SOP QC Acceptance Limits.
IS	Spiked in every sample.	IS intensity within 30-120% of intensity of IS in ICAL.	Re-analyze sample at 5X dilution with the addition of appropriate amounts of IS.		Precision and Accuracy	Same as SOP QC Acceptance Limits.

SAP Worksheet #28-4—Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Wet Chemistry, Ions (NAIPs)

Analytical Method/SOP Reference: SW-846 9056/WETS-057

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per preparatory batch.	No target analytes > 1/2 LOQ.	Correct problem; then repeat. If the method blank still fails; repeat ICAL	Analyst	Bias/ contamination	Same as QC Acceptance Limits.
LCS containing all analytes to be reported		Refer to **Worksheet #15**.	LCS is reanalyzed. If still fails, samples, along with QC, are re-prepped and reanalyzed. Client will be contacted for guidance about whether to re-prep samples. In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
MS and MSD		Same as LCS; RPD ≤ 10%.	In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
Sample Duplicate	One per every 10 samples.	%D ≤ 10% (between sample and sample duplicate).	Correct problem and reanalyze sample and duplicate.		Precision	Same as QC Acceptance Limits.

SAP Worksheet #28-5—Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Wet Chemistry, Sulfide (NAIPs)

Analytical Method/SOP Reference: 18 SM 4500-S-E/WETS-061

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per preparatory blank	No target analytes > 1/2 LOQ.	Correct problem; then repeat. If the method blank still fails; repeat ICAL.	Analyst	Bias/ contamination	Same as QC Acceptance Limits.
LCS		Refer to **Worksheet #15**.	LCS is reanalyzed. If still fails, samples, along with QC, are re-prepped and reanalyzed. Client will be contacted for guidance about whether to re-prep samples. In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
MS and MSD		Same as LCS; RPD ≤ 10%.	In the absence of client-specific requirements, flag the data		Precision and Accuracy/Bias	Same as QC Acceptance Limits.

SAP Worksheet #28-6—Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Wet Chemistry, Alkalinity (NAIPs)

Analytical Method/SOP Reference: EPA 310.2 / WETS-047

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per preparatory batch.	No target analytes > 1/2 LOQ.	Correct problem; then repeat. If the method blank still fails; repeat ICAL.	Analyst	Bias/ contamination	Same as QC Acceptance Limits.
LCS		Refer to **Worksheet #15**.	LCS is reanalyzed. If still fails, samples, along with QC, are re-prepped and reanalyzed. Client will be contacted for guidance about whether to re-prep samples. In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
MS and MSD		Same as LCS; RPD ≤ 10%.	In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.

SAP Worksheet #28-7—Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Wet Chemistry, TOC (NAIPs)

Analytical Method/SOP Reference: SW-846 9060A / WETS-066

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Method Blank	One per preparatory batch.	No target analytes > 1/2 LOQ.	Correct problem; then repeat. If the method blank still fails; repeat ICAL.	Analyst	Bias/ contamination	Same as QC Acceptance Limits.
LCS		Refer to **Worksheet #15**.	LCS is reanalyzed. If still fails, samples, along with QC, are re-prepped and reanalyzed. Client will be contacted for guidance about whether to re-prep samples. In the absence of client-specific requirements, flag the data.		Precision and Accuracy/Bias	Same as QC Acceptance Limits.
MS/MSD		Same as LCS; RPD ≤ 21%.	In the absence of client-specific requirements, flag the data		Precision and Accuracy/Bias	Same as QC Acceptance Limits.

SAP Worksheet #28-8—Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Microbials

Analytical Method/SOP Reference: qPCR / MI SOP qPCR

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	Measurement Performance Criteria
Assay Negative Control (Blank)	1 per analytical assay plate	Values for positive samples are set above any fluorescence for the negative control.	Rerun assay; may have to reoptimize assay.	Analyst	Accuracy/Bias, Contamination	Values for positive samples are set above any fluorescence for the negative control.
Deoxyribonucleic acid (DNA) extraction negative control	1 per analytical batch	Cycle threshold (CT) ≤ Assay Negative Control	Rerun assay or reextract samples if problem persists	Analyst	Accuracy/Bias	CT ≤ Assay Negative Control
Positive Control	1 per analytical assay plate	CT value within 2 units of same point on standard curve	Rerun assay / check reagents	Analyst	Accuracy/Bias	CT value within 2 units of same point on standard curve

SAP Worksheet #29—Project Documents and Records Table

Sample Collection Documents and Records	Onsite Analysis Documents and Records	Offsite Analysis Documents and Records	Data Assessment Documents and Records	Other
• Field Notebooks • Chain-of-Custody Records • Airbills • Custody Seals • CA Forms • Electronic Data Deliverables • ID of QC Samples • Meteorological Data from Field (Logging daily weather) • Sampling locations and sampling plan • Sampling notes	• No onsite analysis will take place	• Sample Receipt, Chain-of-Custody, and Tracking Records • Standard Traceability Logs • Equipment Calibration Logs • Sample Prep Logs • Run Logs • Equipment Maintenance, Testing, and Inspection Logs • CA Forms • Reported Field Sample Results • Reported Result for Standards, QC Checks, and QC Samples • Instrument printouts (raw data) for Field Samples, Standards, QC Checks, and QC Samples • Data Package Completeness Checklists • Sample disposal records • Extraction/Clean-up Records • Raw Data (stored on disk)	• Fixed Laboratory Audit Checklists • Data Validation Reports • CA Forms • Laboratory QA Plan • Method DL Study Information	•

Notes:
Sample collection documents and records will be scanned and saved on the network server. Field parameters will be loaded into the database using the Field Data Entry Tool.
Offsite analysis documents and records will be archived after a period of 6 months. Hardcopy deliverables from the data validator, as well as other data assessment documents and records, will be archived. All archived documents will be archived with Iron Mountain, Inc., headquartered at 745 Atlantic Avenue, Boston, Massachusetts, 02111.

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SAP Worksheet #30—Analytical Services Table

Matrix	Analytical Group	Sample Locations/ID Number	Analytical Method	Data Package Turnaround Time	Laboratory / Organization	Backup Laboratory / Organization
Pore Water	VOCs	Refer to **Worksheets #18 and #20**	VOCs by SW-846 8260B	28 calendar days	ENCO-Orlando 10775 Central Port Drive Orlando, FL 32824 Ronnie Wambles (407) 826-5314	TBD
Groundwater	VOCs		VOCs by SW-846 8260B			
	NAIPS		Methane, ethane, and ethene by RSK-175		ENCO-Jacksonville 4810 Executive Park Court, Suite 111 Jacksonville, FL 32216 Ronnie Wambles (407) 826-5314	
			Iron and Manganese by SW-846 6020A		ENCO-Orlando (see information above)	
			Chloride and sulfate by SW-846 9056A			
			Sulfide by SM 18 4500-S-E			
			Alkalinity by EPA 310.2			
			TOC by SW 846 9060A			
	Microbials		DHC and functional genes by qPCR		Microbial Insights, Inc. 2340 Stock Creek Blvd Rockford, TN 37853 Anita Biernacki (865) 573-8188	

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SAP 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 CA	Person(s) Responsible for Monitoring Effectiveness of CA
Field Performance Audit	One during sampling activities	Internal	CH2M HILL	Theron Grim PM CH2M HILL	FTL CH2M HILL	Theron Grim PM CH2M HILL	Theron Grim PM CH2M HILL
Offsite Laboratory Technical Systems Audit	Laboratory must have current DoD Environmental Laboratory Accreditation Program (ELAP) evaluation letter which will identify the period of performance. The laboratory must be re-evaluated prior to expiration of the period of performance.[1]	External	Third-Party Accrediting Body	TBD, Third-Party Accrediting Body	Lori Mangram QAO ENCO-Orlando and ENCO-Jacksonville	Lori Mangram QAO ENCO-Orlando and ENCO-Jacksonville	Anita Dodson, Program Chemist, CH2M HILL
Safe Behavior Observation	One during sampling activities	Internal	CH2M HILL	Site Safety Coordinator CH2M HILL	Field Team Member observed CH2M HILL	Carl Woods H&S Manager CH2M HILL	Site Safety Coordinator CH2M HILL

[1] DoD ELAP audits are not applicable to Microbial Insights because no DoD certification exists for the microbials to be analyzed at Microbial Insights.

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SAP Worksheet #32—Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of CA Response Documentation	Individual(s) Receiving Response	Timeframe for Response
Field Performance Audit	Checklist and Written Audit Report	FTL CH2M HILL	Within 1 day of audit	Verbal and Memorandum	FTL CH2M HILL	Within 1 day of receipt of CA Form
Laboratory Performance and Systems Audits	Written Audit Report	Lori Mangram QAO ENCO-Orlando and ENCO-Jacksonville	Within 2 months of audit	Memorandum	DoD ELAP Auditor	Within 2 months of receipt of initial notification.
Safe Behavior Observation	Safe Behavior Observation Form	Carl Woods H&S Manager CH2M HILL	Within 1 week of safe behavior observation.	Memorandum	Field Team Member CH2M HILL	Immediately

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SAP Worksheet #32-1—Corrective Action Form

Person initiating CA _____ **Date** _____

Description of problem and when identified: _____

_____

_____

_____

_____

Cause of problem, if known or suspected: _____

_____

_____

_____

<u>Sequence of CA:</u> (including date implemented, action planned and personnel/data affected)

_____

_____

_____

_____

_____

_____

_____

_____

CA implemented by: _____ **Date:** _____

CA initially approved by: _____ **Date:** _____

Follow-up date: _____

Final CA approved by: _____ **Date:** _____

Information copies to:

<u>Anita Dodson, CH2M HILL Navy CLEAN Program Chemist</u>

_____

_____

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SAP Worksheet #32-2—Field Performance Audit Checklist

Project Responsibilities

Project No.: _____ Date: _____

Project Location: _____ Signature: _____

Team Members:

Yes _ No _ 1) Is the approved work plan being followed?

Comments _____

_____

Yes _ No _ 2) Was a briefing held for project participants?

Comments _____

_____

Yes _ No _ 3) Were additional instructions given to project participants?

Comments _____

_____

Sample Collection

Yes _ No _ 1) Is there a written list of sampling locations and descriptions?

Comments _____

_____

Yes _ No _ 2) Are samples collected as stated in the Master SOPs?

Comments _____

_____

Yes _ No _ 3) Are samples collected in the type of containers specified in the work plan?

Comments _____

_____

Yes _ No _ 4) Are samples preserved as specified in the work plan?

Comments _____

_____

Yes _ No _ 5) Are the number, frequency, and type of samples collected as specified in the work plan?

Comments _____

_____

SAP Worksheet #32-2—Field Performance Audit Checklist (continued)

Yes _ No _ 6) Are QA checks performed as specified in the work plan?

Comments _____

_____

Yes _ No _ 7) Are photographs taken and documented?

Comments _____

_____

Document Control

Yes _ No _ 1) Have any accountable documents been lost?

Comments _____

_____

Yes _ No _ 2) Have any accountable documents been voided?

Comments _____

_____

Yes _ No _ 3) Have any accountable documents been disposed of?

Comments _____

Yes _ No _ 4) Are the samples identified with sample tags?

Comments _____

_____

Yes _ No _ 5) Are blank and duplicate samples properly identified?

Comments _____

_____

Yes _ No _ 6) Are samples listed on a chain-of-custody record?

Comments _____

_____

Yes _ No _ 7) Is chain-of-custody documented and maintained?

Comments _____

_____

SAP Worksheet #33—QA Management Reports Table

Type of Report	Frequency	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Field Audit Report	One during sampling activities	Submitted with Final Report	Theron Grim PM CH2M HILL	Included in project files.

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SAP Worksheets #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification (name, organization)	Step I / IIa / IIb[1]	Internal / External[2]
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	FTL: Kristin Rogers/CH2M HILL	I	Internal
Chains of Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody will be initialed by the reviewer, a copy of the chain-of-custody form retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chain-of-custody forms will also be reviewed for adherence to the SAP by the Project Chemist.	FTL: Kristin Rogers/CH2M HILL PDM: Troy Horn/CH2M HILL Project Chemist: Clairette Campbell/CH2M HILL	I	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the PDM in the form of laboratory logins.	PDM: Troy Horn/CH2M HILL	I	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the project chemist. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	Project Chemist: Clairette Campbell/CH2M HILL	I	External
Electronic Data Deliverables	Electronic Data Deliverables will be compared against hardcopy laboratory results (10 percent check).	PDM: Troy Horn/CH2M HILL	I	External
Case Narrative	Case narratives will be reviewed by the data validator during the data validation process. This is verification that they were generated and applicable to the data packages.	Data Validation Subcontractor: Laura Maschhoff/DataQual	I	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Laboratory QAO (ENCO-Orlando) Laboratory QAO (Microbial Insights)	I/IIa	Internal

SAP Worksheets #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table (continued)

Data Review Input	Description	Responsible for Verification (name, organization)	Step I / IIa / IIb[1]	Internal / External[2]
Laboratory Data	The data will be verified for completeness by the PDM.	PDM: Troy Horn/CH2M HILL	I	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If CAs are required, a copy of the documented CA taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and CA forms will be reviewed internally to ensure that all appropriate CAs have been taken and that CA reports are attached. If CAs have not been taken, the site manager will be notified to ensure action is taken.	PM: Theron Grim/CH2M HILL Project Chemist: Clairette Campbell/CH2M HILL	I	Internal
CA Reports	CA reports will be reviewed by the Project Chemist or PM and placed into the project file for archival at project closeout.	PM: Theron Grim/CH2M HILL Project Chemist: Clairette Campbell/CH2M HILL	I	External
Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods.	Project Chemist: Clairette Campbell/CH2M HILL	IIa	External
Target Compound List and Target Analyte List	Ensure the laboratory reported all analytes from each analysis group.	Project Chemist: Clairette Campbell/CH2M HILL	I/IIa	External
Reporting Limits	Ensure the laboratory met the project-designated QLs. If QLs were not met, the reason will be identified and documented.	Project Chemist: Clairette Campbell/CH2M HILL	IIb	External
Field SOPs	Ensure that all field SOPs were followed.	FTL: Kristin Rogers/CH2M HILL	IIa	Internal

SAP Worksheets #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table (continued)

Data Review Input	Description	Responsible for Verification (name, organization)	Step I / IIa / IIb[1]	Internal / External[2]
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Respective Laboratory QAOs	IIa	Internal
Raw Data	10 percent review of raw data to confirm laboratory calculations.	Data Validation Subcontractor: Laura Maschhoff/DataQual	IIa	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	FTL: Kristin Rogers/CH2M HILL	IIb	Internal
Documentation of Method QC Results	Establish that all required QC samples were run.	Data Validation Subcontractor: Laura Maschhoff/DataQual	IIa	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run.	Project Chemist: Clairette Campbell	IIb	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP Certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	Project Chemist: Clairette Campbell/CH2M HILL	IIb	External
Groundwater and/or Pore Water: VOCs	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. The data qualifiers used are those presented in *National Functional Guidelines for Organic Data Review (EPA, October 1999).* National Functional Guidelines will not be used for data validation; however, the specific qualifiers listed therein may be applied to data should non-conformances against the QA/QC criteria as presented in this SAP be identified.	Data Validation Subcontractor: Laura Maschhoff/DataQual	IIa	External

SAP Worksheets #34-36—Data Verification and Validation (Steps I and IIa/IIb) Process Table (continued)

Data Review Input	Description	Responsible for Verification (name, organization)	Step I / IIa / IIb[1]	Internal / External[2]
Groundwater: NAIPs (dissolved gases, metals, wet chemistry), and microbials	Dissolved gases, metals, wet chemistry, and microbials, will not undergo third-party data validation but are subject to all other data review protocols previously detailed.	NA	NA	NA

[1] Verification (Step I) is a completeness check that is performed before the data review process continues in order to determine whether the required information (complete data package) is available for further review. Validation (Step IIa) is a review that the data generated is in compliance with analytical methods, procedures, and contracts. Validation (Step IIb) is a comparison of generated data against measurement performance criteria in the SAP (both sampling and analytical).

[2] Internal or external is in relation to the data generator.

SAP Worksheet #37—Usability Assessment

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:

- Non-detected site contaminants will be evaluated to ensure that project required LODs (**Worksheet #15)** were achieved. If LODs were achieved and the verification and validation steps yielded acceptable data, then the data is considered usable.
- The third-party data validator is the only party that may apply qualifiers to the data. Minor QC exceedances will result in "estimated" data, represented by J, NJ, and UJ qualifiers. Major QC exceedances will result in "rejected" data, represented by R-qualifiers. The effect on availability and usability of rejected results will be evaluated.
- For statistical comparisons, non-detect values will be represented by a concentration equal to one-half the sample LOD. For duplicate sample results, the most conservative value will be used for project decisions.
- Analytical data will be checked to ensure the values and any qualifiers are appropriately transferred to the electronic database. These checks include comparison of hardcopy data and qualifiers to the electronic data deliverable. Once the data have been uploaded into the electronic database, another check will be performed to ensure all results were loaded accurately.
- Field and laboratory precision will be compared as the RPD between the two results. If the Measurement Performance Criteria defined in **Worksheet#12** are exceeded, the data will be J-qualified.
- Deviations from this UFP-SAP will be reviewed to assess whether CA is warranted and to assess impacts to achievement of project objectives.

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

- To assess whether a sufficient quantity of acceptable data are available for decision-making, the data will be reconciled with measurement performance criteria following validation and review of DQIs.
- If significant biases are detected with laboratory QA/QC samples, they will be evaluated to assess their impact on decision-making. Low biases will be described in greater detail because they represent a possible inability to detect compounds that may be present at the site.
- If significant deviations are noted between lab and field precision, the cause will be further evaluated to assess their impact on decision-making.

SAP Worksheet #37—Usability Assessment (continued)

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

- Data tables will be produced to reflect detected and non-detected site COCs and geochemical parameters. Data qualifiers will be reflected in the tables and discussed in the data quality evaluation.
- Figures will be produced to reflect areas of investigation, including environmental sampling locations and results.
- If needed, a technical memorandum will be produced that will identify any data usability limitations and make recommendations for CA.

Identify the personnel responsible for performing the usability assessment.

The CH2M HILL team, including the PM and Project Chemist, will review the data and compile a presentation for the MCB CamLej Partnering Team. The MCB CamLej Partnering Team as a whole will assess the usability of the data.

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Figures

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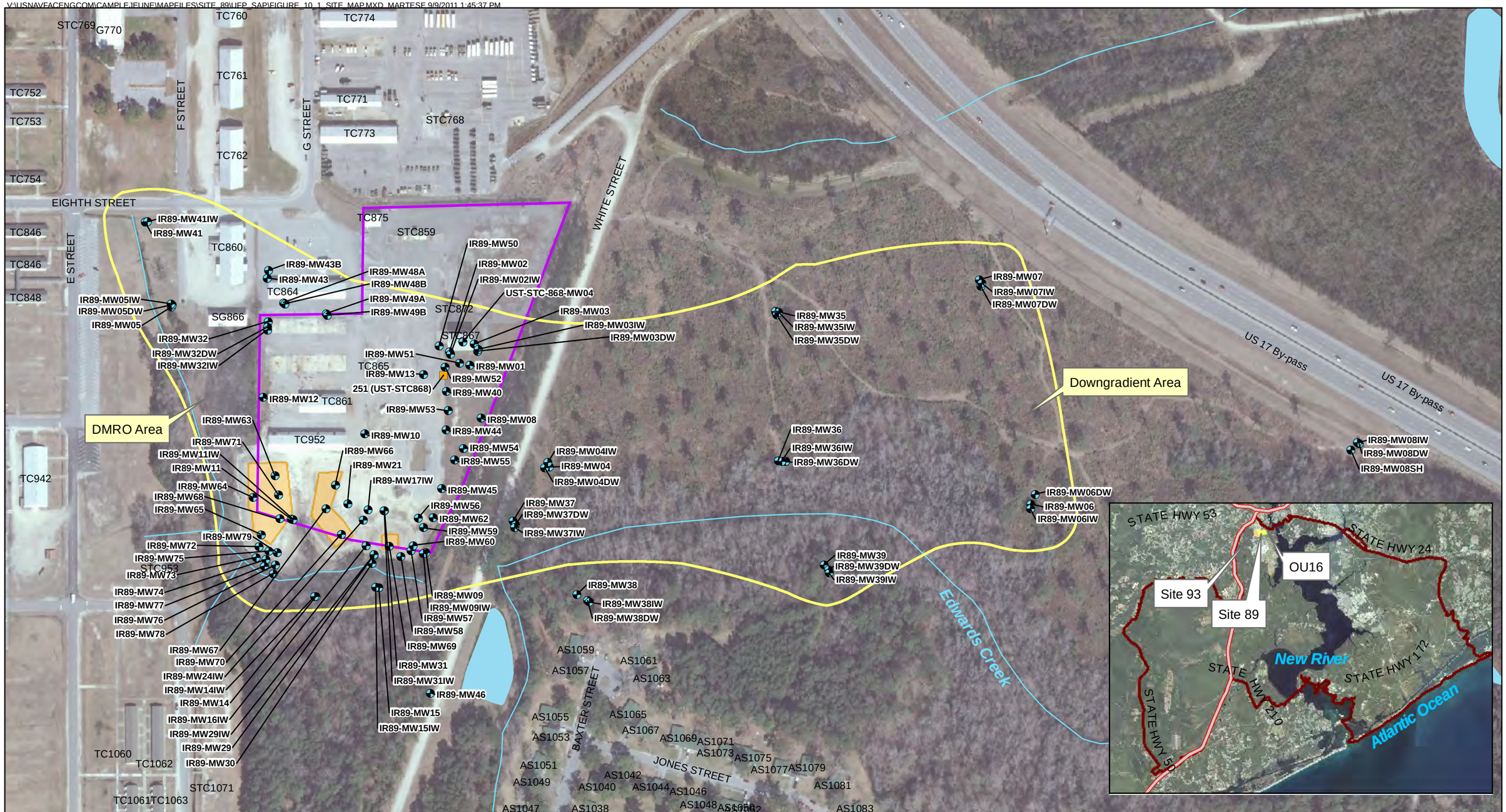

Legend

- Former UST Locations
- Monitoring Well Locations
- Site 89 Boundary
- Former Defense Reutilization and Marketing Office Area
- Soil Mixing Treatment Areas

N

0 250 500 Feet

1 inch = 250 feet

Figure 10-1
Site Map
Site 89 UFP-SAP
MCB CamLej
North Carolina

CH2MHILL

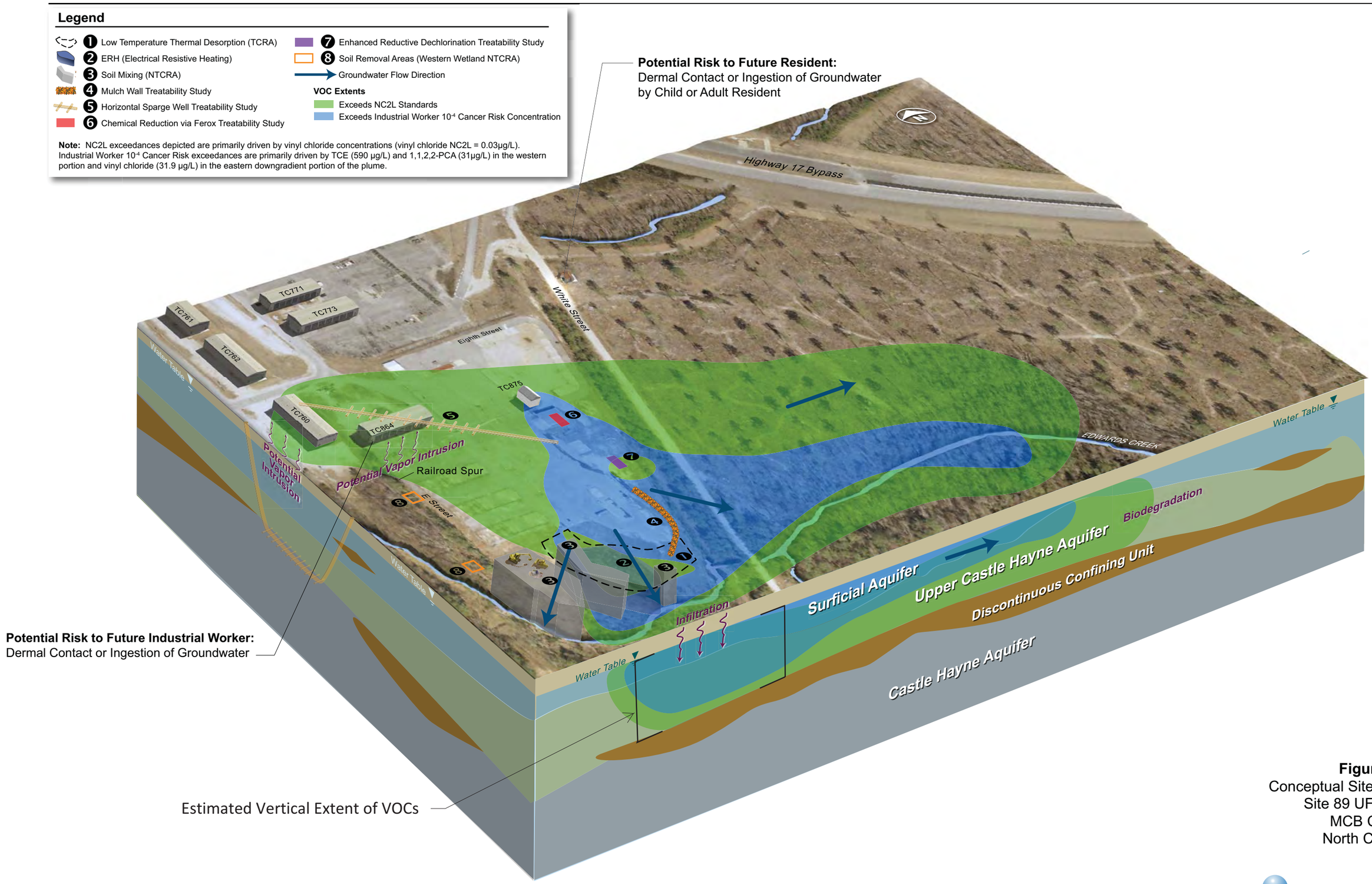

Figure 10-2
Conceptual Site Model
Site 89 UFP-SAP
MCB CamLej
North Carolina

CH2MHILL

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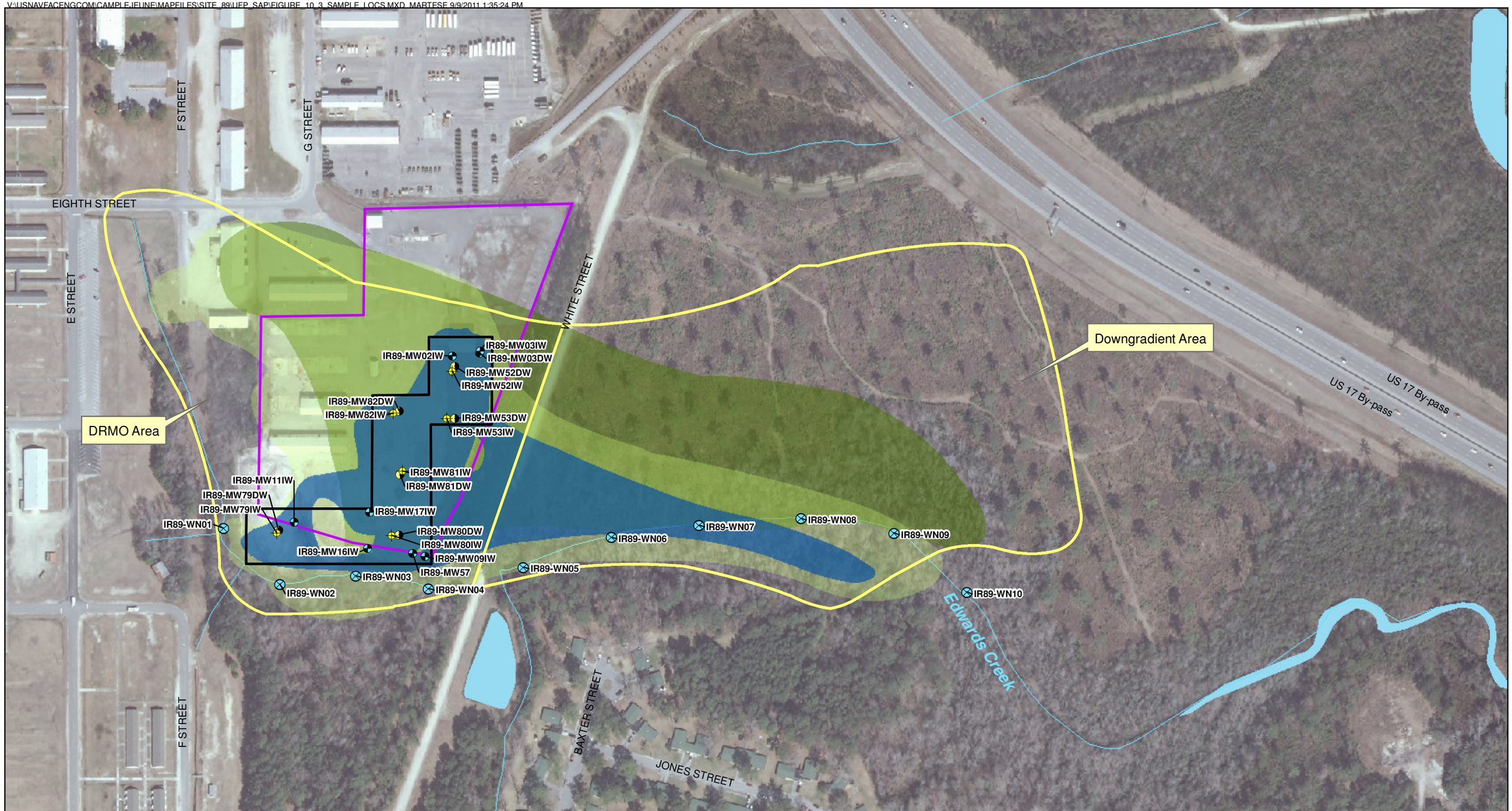

Legend

- Proposed Upper Castle Hayne Aquifer MW
- Proposed Middle Castle Hayne Aquifer MW
- Proposed Pore Water Sample Location
- Monitoring Well Locations
- Site 89 Boundary
- Active Treatment Area
- Former DRMO Area
- Exceeds Industrial Worker 10^{-4} Cancer Risk
- Surficial Groundwater - Exceeds NCGWQS/MCL
- Upper Castle Hayne Groundwater - Exceeds NCGWQS/MCL

N

0 250 500 Feet

1 inch = 250 feet

Figure 10-3
Sample Locations
Site 89 UFP-SAP
MCB CamLej
North Carolina

CH2MHILL

Attachment 1
Site Health and Safety Plan

Health and Safety Plan

Site 89 Monitoring Well Installation and Sampling

Prepared for

MCB Camp Lejeune

Jacksonville, NC

September 2011

CH2MHILL

3201 Beechleaf Court Tower II - Suite 300
Raleigh, NC 27604

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Approval

This site-specific Health and Safety Plan (HSP) has been written for use by CH2M HILL only. CH2M HILL claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions and identified scope(s) of work and must be amended if those conditions or scope(s) of work change.

By approving this HSP, the Responsible Health and Safety Manager (RHSM) certifies that the personal protective equipment has been selected based on the project-specific hazard assessment.

Original Plan

RHSM Approval: Carl Woods **Date**: 9/6/11

Field Operations Manager Approval: **Date:**

Revisions

Revisions Made By: **Date:**

Description of Revisions to Plan:

Revisions Approved By: **Date:**

1.0 Introduction

CH2MHILL

HSSE Target Zero World-Class Performance

Health, Safety, Security, and Environment Policy

Protection of people and the environment is a CH2M HILL core value. It is our vision to create a culture within CH2M HILL that empowers employees to drive this value into all global operations and achieve excellence in health, safety, security, and environment (HSSE) performance. CH2M HILL deploys an integrated, enterprise-wide behavior-based HSSE management system to fulfill our mission and the expectations of our clients, staff, and communities based on the following principles:

- We require all management and supervisory personnel to provide the leadership and resources to inspire and empower our employees to take responsibility for their actions and for the actions of their fellow employees to create a safe, healthy, secure, and environmentally-responsible workplace.
- We provide value to clients by tailoring HSSE processes to customer needs and requiring all CH2M HILL employees and subcontractors to deliver projects with agility, personal service, and responsiveness and in compliance with HSSE requirements and company standards to achieve health, safety, security, and pollution prevention excellence. Our performance will aspire to influence others and continually redefine world-class HSSE excellence.
- We systematically evaluate our design engineering and physical work environment to verify safe and secure work conditions and practices are established, consistently followed, and timely corrected.
- We continually assess and improve our HSSE program to achieve and maintain world-class performance by setting and reviewing objectives and targets, reporting performance metrics, and routinely reviewing our progress.
- We care about the safety and security of every CH2M HILL employee and expect all employees to embrace our culture, share our core value for the protection of people and the environment, understand their obligations, actively participate, take responsibility, and "walk the talk" on and off the job.

The undersigned pledge our leadership, commitment, and accountability for making this policy a reality at CH2M HILL.

Dated the 1st day of October 2009.

Lee A. McIntire
Chief Executive Officer

Garry Higdem
President, Energy Division

Jacqueline Rast
President, Major Programs Group

Robert C. Allen
Chief Human Resources Officer

Mark Lasswell
President, Transportation Business Group

Catherine Santee
Chief Financial Officer

Bob Card
President, Facilities & Infrastructure Division

Margaret McLean
Chief Legal Officer

Thomas G. Searle
President, International Division

Bill Dehn
Senior Vice President, Special Projects

Michael E. McKelvy
President, Government, Environment, and Nuclear Division

Nancy R. Tuor
Vice-Chair, International

Keith Christopher
Senior Vice President, Health, Safety, Security, and Environment

1.1 CH2M HILL Policy and Commitment

1.1.1 Safe Work Policy

It is the policy of CH2M HILL to perform work in the safest manner possible. Safety must never be compromised. To fulfill the requirements of this policy, an organized and effective safety program must be carried out at each location where work is performed.

CH2M HILL believes that all injuries are preventable, and we are dedicated to the goal of a safe work environment. To achieve this goal, every employee on the project must assume responsibility for safety.

Every employee is empowered to:

- Conduct their work in a safe manner;
- Stop work immediately to correct any unsafe condition that is encountered; and
- Take corrective actions so that work may proceed in a safe manner.

Safety, occupational health, and environmental protection will not be sacrificed for production. These elements are integrated into quality control, cost reduction, and job performance, and are crucial to our success.

1.1.2 Health and Safety Commitment

CH2M HILL has embraced a philosophy for health and safety excellence. The primary driving force behind this commitment to health and safety is simple: employees are CH2M HILL's most significant asset and CH2M HILL management values their safety, health, and welfare. Also, top management believes that all injuries are preventable. CH2M HILL's safety culture empowers employees at all levels to accept ownership for safety and take whatever actions are necessary to eliminate injury. Our company is committed to world-class performance in health and safety and also understands that world-class performance in health and safety is a critical element in overall business success.

CH2M HILL is committed to the prevention of personal injuries, occupational illnesses, and damage to equipment and property in all of its operations; to the protection of the general public whenever it comes in contact with the Company's work; and to the prevention of pollution and environmental degradation.

Company management, field supervisors, and employees plan safety into each work task in order to prevent occupational injuries and illnesses. The ultimate success of CH2M HILL's safety program depends on the full cooperation and participation of each employee.

CH2M HILL management extends its full commitment to health and safety excellence.

1.1.3 Project-Specific Health, Safety, and the Environment Goals

All management and employees are to strive to meet the project-specific Health, Safety, and the Environment (HSE) goals outlined below. The team will be successful only if everyone makes a concerted effort to accomplish these goals. The goals allow the project to stay focused on optimizing the health and safety of all project personnel and, therefore, making the project a great success.

The Project has established eleven specific goals and objectives:

- Create an injury-free environment;
- Have zero injuries or incidents;
- Provide management leadership for HSE by communicating performance expectations, reviewing and tracking performance, and leading by example;

- Ensure effective implementation of the HSP through education, delegation, and team work;
- Ensure 100 percent participation in HSE compliance;
- Continuously improve our safety performance;
- Maintain free and open lines of communication;
- Make a personal commitment to safety as a value;
- Focus safety improvements on high-risk groups;
- Continue strong employee involvement initiatives; and
- Achieve health and safety excellence.

2.0 Applicability

This HSP applies to:

- All CH2M HILL staff, including subcontractors and tiered subcontractors of CH2M HILL working on the site; and
- All visitors to the construction site in the custody of CH2M HILL (including visitors from the Client, the Government, the public, and other staff of any CH2M HILL company).

This HSP does not apply to the third-party contractors, their workers, their subcontractors, their visitors, or any other persons not under the direct control or custody of CH2M HILL.

This HSP defines the procedures and requirements for the health and safety of CH2M HILL staff and visitors when they are physically on the work site. The work site includes the project area (as defined by the contract documents) and the project offices, trailers, and facilities thereon.

This HSP will be kept onsite during field activities and will be reviewed as necessary. The HSP will be amended or revised as project activities or conditions change or when supplemental information becomes available. The HSP adopts, by reference, the Enterprise-wide Core Standards and Standard Operating Procedures (SOPs), as appropriate. In addition, the HSP may adopt procedures from the project Work Plan and any governing regulations. If there is a contradiction between this HSP and any governing regulation, the more stringent and protective requirement shall apply.

All CH2M HILL staff and subcontractors must sign the employee sign-off form included in this document as Attachment 1 to acknowledge review of this document. Copies of the signature page will be maintained onsite by the Safety Coordinator (SC).

3.0 General Project Information

3.1 Project Information and Background

Project Number: 423868

Client: Department of Navy/MCB Camp Lejeune

Project/Site Name: Site 89 Monitoring Well Installation and Sampling

Site Address: MCB CampLej, Site 89, Jacksonville, NC

CH2M HILL Project Manager: Theron Grim/CLT

CH2M HILL Office: Raleigh, NC

DATE HSP Prepared: 9/6/11

Date(s) of Site Work: November – December 2011

Site Access: Access to the site is restricted. The site is fenced in and is located on a MCB Camp Lejeune military base. The site is located southeast of the intersection of "G" and Eighth Streets.

3.2 Site Background and Setting

MCB Camp Lejeune is located in Onslow County, North Carolina and covers approximately 236 square miles and includes 14 miles of coastline. The Base is bounded to the southeast by the Atlantic Ocean and to the northeast by State Route 24. The town of Jacksonville, North Carolina is located north of the Base. Site 89 is one of two sites within Operable Unit 16 and is located southeast of the intersection of "G" and Eighth Streets of MCB Camp Lejeune. Site 93 is the other site of the Operable Unit 16 and is located immediately west of Site 89. Site 89 consists of a fenced area of the DRMO that is generally covered by gravel and asphalt and was used primarily for staging and storage of equipment, vehicles and supplies. Heavily wooded areas are present east and south of the fenced area of Site 89. A housing unit for MCB Camp Lejeune is located southeast of Site 89. Edwards Creek is located west and south of the fenced area of Site 89 and flows east through the wooded and marshy area east of the Site 89. The Base Motor Pool operated on Site 89 until approximately 1988. Historical records indicated that the Base Motor Pool had used chemical materials that included acetone, trichloroethene (TCE), and 2-butanone (methyl-ethyl-ketone [MEK]). A 550-gallon steel underground storage tank (UST) was installed at the site in 1983 to store waste oil, but was later removed in 1993. In addition, fuel bladders (mobile storage tanks) that ranged in size from 600 gallons to 20,000 gallons were stored within the DRMO until their disposal.

See Site Map for work area.

3.3 Description of Tasks

All CH2M HILL and Subcontractor employees engaging in hazardous waste operations (HAZWOPER) or emergency response shall receive appropriate training as required by 29 CFR 1910.120 and 29 CFR 1926.65 (or if required by Subcontract). Personnel who have not met these training requirements shall not be allowed to engage in hazardous waste operations or emergency response activities. See the following tasks that fall under HAZWOPER requirements.

3.3.1 HAZWOPER-Regulated Tasks

This Supplemental Investigation includes permanent monitoring well installation, groundwater sampling, and pore water sampling.

Refer to project documents (i.e., UFP-SAP) for detailed task information. Tasks include overseeing subcontractors, collecting groundwater samples, installing pore water sample points, and collecting pore water samples.

- Subcontractor Oversight
- Groundwater Sampling
- Monitoring Well Installation & Pore Water Sample Points
- Pore Water Sample Collection

3.3.2 Non-HAZWOPER-Regulated Tasks

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. The following tasks do not involve exposure to safety or health hazards associated with the hazardous waste operations. Hazwoper training or medical requirements do not apply for the tasks listed below.

TASKS

- Survey
- Utility Locating (non-intrusive)

CONTROLS

- Brief on hazards, limits of access, and emergency procedures.
- Post areas of contamination as appropriate.
- Perform air sampling/monitoring as specified in this HSP.

Site Map

DMRO Area
Downgradient Area
EIGHTH STREET
WHITE STREET
Eleanor Creek
OU16
Site 93
Site 99
New River
Atlantic Ocean

4.0 Project Organization and Responsibilities

4.1 Client

Contact Name: Charity Rychak
Phone: 910-451-9386
Facility Contact Name:
Phone:

4.2 CH2M HILL

4.2.1 Project Manager

PM Name: Theron Grim
CH2M HILL Office: Charlotte
Telephone Number: 704-544-4065
Cellular Number: 908-268-5952

The project manager (PM) is responsible for providing adequate resources (budget and staff) for project-specific implementation of the HSE management process. The PM has overall management responsibility for the tasks listed below. The PM may explicitly delegate specific tasks to other staff, as described in sections that follow, but retains ultimate responsibility for completion of the following in accordance with this document:

- Incorporate standard terms and conditions, and contract-specific HSE roles and responsibilities in contract and subcontract agreements (including flow-down requirements to lower-tier subcontractors).
- Select safe and competent subcontractors by:
  - Choosing potential subcontractors based on technical ability and HSE performance;
  - Implementing the subcontractor prequalification process;
  - Ensuring that acceptable certificates of insurance, including CH2M HILL as named additional insured, are secured as a condition of subcontract award; and
  - Ensuring HSE submittals, subcontract agreements, and appropriate site-specific safety procedures are in place and accepted prior field mobilization.
- Ensure copies of training and medical monitoring records, and site-specific safety procedures are being maintained in the project file accessible to site personnel.
- Provide oversight of subcontractor HSE practices per the site-specific safety plans and procedures.
- Manage the site and interfacing with 3rd parties in a manner consistent with the contract and subcontract agreements and the applicable standard of reasonable care.
- Ensure that the overall, job-specific, HSE goals are fully and continuously implemented.
- Support and implement use of stop-work orders when subcontractor safety performance is not adequate.

4.2.2 CH2M HILL Responsible Health and Safety Manager

RHSM Name: Carl Woods CH2M HILL Office: Cincinnati, Ohio Telephone Number: (513) 889-5771 Mobile Number: (513) 319-5771

The RHSM is responsible for the following:

- Review and evaluate subcontractor HSE performance using the pre-qualification process;
- Approve HSP and its revisions as well as Activity Hazard Analyses (AHA);
- Review and evaluate subcontractor site-specific safety procedures for adequacy prior to start of subcontractor's field operations;
- Support the oversight (or SC's direct oversight) of subcontractor and tiered subcontractor HSE practices;
- Permit upgrades and downgrades in respiratory protection after reviewing analytical data;
- Conduct audits as determined by project schedule and coordination with PM; and
- Participate in incident investigations, lessons learned, loss and near loss reporting.

4.2.3 CH2M HILL Project Environmental Manager

EM Name: Hope Wilson CH2M HILL Office: ATL Telephone Number: 678-530-4426 Cellular Number: 678-656-5411

The Project EM is responsible for the following:

- Provide environmental program support in areas such as training, auditing, planning, permit tracking, and subcontractor oversight as needed or as specified in the project environmental plan;
- Review and evaluate qualifications for subcontractors with a history of environmental non-compliance and for waste transportation and disposal subcontractors;
- Evaluate any spills, releases, or environmental permit incidents for appropriate follow-up actions, notifications, and recordkeeping requirements; and
- Provide environmental compliance and environmental management expertise and advice to the project team as needed during the course of the project.

4.2.4 CH2M HILL Safety Coordinator

SC Name: Kristin Rogers CH2M HILL Office: Raleigh Telephone Number: 919-760-1789 Cellular Number: 765-409-4278

The SC is responsible for verifying that the project is conducted in a safe manner including the following specific obligations:

- Verify this HSP is current and amended when project activities or conditions change;
- Verify CH2M HILL site personnel and subcontractor personnel read the HSP and sign the Employee Sign-Off Form, prior to commencing field activities;

- Verify CH2M HILL site personnel have completed any required specialty training (for example, fall protection, confined space entry, among others) and medical surveillance as identified in this HSP;
- Verify that project files include copies of subcontractor training and medical monitoring records, and accepted site-specific safety procedures prior to start of subcontractor's field operations;
- Act as the project "Hazard Communication Coordinator" and perform the responsibilities outlined in the HSP;
- Act as the project "Emergency Response Coordinator" and perform the responsibilities outlined in the HSP;
- Post the Occupational Safety and Health Administration (OSHA) job-site poster; the poster is required at sites where project field offices, trailers, or equipment-storage boxes are established. If you work in a state with an OSHA State Plan, make sure the State Plan poster is posted, if required;
- Hold and/or verify that safety meetings are conducted and documented in the project file initially and as needed throughout the course of the project (as tasks or hazards change);
- Verify that project health and safety forms and permits are being used as outlined this HSP;
- Perform oversight and assessments of subcontractor HSE practices per the site-specific safety plan and verify that project activity self-assessment checklists are being used as outlined this HSP;
- Coordinate with the RHSM regarding CH2M HILL and subcontractor operational performance, and 3rd party interfaces;
- Verify appropriate personal protective equipment (PPE) use, availability, and training;
- Ensure that the overall, job-specific, HSE goals are fully and continuously implemented;
- Conduct accident investigations including root cause analysis;
- Calibrate and conduct air monitoring in accordance with the HSP; maintain all air monitoring records in project file;
- Maintain HSE records and documentation;
- Facilitate OSHA or other government agency inspections including accompanying inspector and providing all necessary documentation and follow-up;
- Deliver field HSE training as needed based on project-specific hazards and activities;
- Contact the RHSM and PM in the event of an incident;
- When an apparent imminent danger exists, immediately remove all affected CH2M HILL employees and subcontractors, notify subcontractor safety representative, stop affected work until adequate corrective measures are implemented, and notify the PM and RHSM as appropriate; and
- Document all oral health and safety-related communications in project field logbook, daily reports, or other records.

4.3 CH2M HILL Subcontractors

(Reference CH2M HILL SOP HSE-215, *Contracts and Subcontracts)*

Subcontractor: Utility Clearance Subcontractor Contact Name: ECLS - Mike Montgomery Telephone: 910-897-3257
Subcontractor: Drilling Subcontractor Contact Name: SAEDACCO – Pete Beyer Telephone: 803-548-2180
Subcontractor: IDW Subcontractor Contact Name: TBD Telephone:
Subcontractor: Surveyor Subcontractor Contact Name: ECLS - Mike Montgomery Telephone: 910-897-3257

Subcontractors must comply with the following activities, and are responsible to:

- Comply with all local, state, and federal safety standards;
- Comply with project and owner safety requirements;
- Actively participate in the project safety program and either hold or attend and participate in all required safety meetings;
- Provide a qualified safety representative to interface with CH2M HILL;
- Maintain safety equipment and PPE for their employees;
- Maintain and replace safety protection systems damaged or removed by the subcontractor's operations;
- Notify the SC of any accident, injury, or incident (including spills or releases) immediately and submit reports to CH2M HILL within 24 hours;
- Install contractually required general conditions for safety (for example, handrail, fencing, fall protection systems, floor opening covers);
- Conduct and document weekly safety inspections of project-specific tasks and associated work areas;
- Conduct site-specific and job-specific training for all subcontractor employees, including review of the CH2M HILL HSP, subcontractor HSPs, and subcontractor AHAs and sign appropriate sign-off forms; and
- Determine and implement necessary controls and corrective actions to correct unsafe conditions.

The subcontractors listed above may be required to submit their own site-specific HSP and other plans such as lead or asbestos abatement compliance plans. Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit their plans to CH2M HILL for review and acceptance before the start of field work.

Subcontractors are also required to prepare AHAs before beginning each activity posing hazards to their personnel. The AHA shall identify the principle steps of the activity, potential health and safety hazards for each step and recommended control measures for each identified hazard. In addition, a

listing of the equipment to be used to perform the activity, inspection requirements, and training requirements for the safe operation of the equipment listed must be identified.

4.4 Employee Responsibilities

All personnel are assigned responsibility for safe and healthy operations. This concept is the foundation for involving all employees in identifying hazards and providing solutions. For any operation, individuals have full authority to stop work and initiate immediate corrective action or control. In addition, each worker has a right and responsibility to report unsafe conditions or practices. This right represents a significant facet of worker empowerment and program ownership. Through shared values and a belief that all accidents are preventable, our employees accept personal responsibility for working safely.

Each employee is responsible for the following performance objectives:

- Perform work in a safe manner and produce quality results;
- Perform work in accordance with company policies, and report injuries, illnesses, and unsafe conditions;
- Complete work without injury, illness, or property damage;
- Report all incidents immediately to supervisor, and file proper forms with a human resources representative;
- Report all hazardous conditions and/or hazardous activities immediately to supervisor for corrective action; and
- Complete an HSE orientation prior to being authorized to enter the project work areas.

4.4.1 Employee Authority

Each employee on the project has the obligation and authority to shut down any perceived unsafe work and during employee orientation, each employee will be informed of their authority to do so.

4.5 Client Contractors

(Reference CH2M HILL SOP HSE-215, *Contracts, Subcontracts and HSE Management Practices*)

Contractor: N/A
Contact Name:
Telephone:
Contractor Task(s):

Contractor:
Contact Name:
Telephone:
Contractor Task(s):

This HSP does not cover contractors that are contracted directly to the client or the owner. CH2M HILL is not responsible for the health and safety or means and methods of the contractor's work, and we must never assume such responsibility through our actions (such as advising on health and safety issues). In addition to these instructions, CH2M HILL team members should review contractor safety plans so that we remain aware of appropriate precautions that apply to us. Self-assessment checklists are to be used by the SC and CH2M HILL team members to review the contractor's performance only as it pertains to evaluating CH2M HILL exposure and safety. The RHSM is the only person who is authorized to comment on or approve contractor safety procedures.

Health and safety-related communications with contractors should be conducted as follows:

- Request the contractor to brief CH2M HILL team members on the precautions related to the contractor's work;
- When an apparent contractor non-compliance or unsafe condition or practice poses a risk to CH2M HILL team members:
  - Notify the contractor safety representative;
  - Request that the contractor determine and implement corrective actions;
  - If necessary, stop affected CH2M HILL work until contractor corrects the condition or practice; and
  - Notify the client, PM, and RHSM as appropriate.

If apparent contractor non-compliance or unsafe conditions or practices are observed, inform the contractor safety representative (CH2M HILL's obligation is limited strictly to informing the contractor of the observation; the contractor is solely responsible for determining and implementing necessary controls and corrective actions).

If an apparent imminent danger is observed, immediately warn the contractor employee(s) in danger and notify the contractor safety representative (CH2M HILL's obligation is limited strictly to immediately warning the affected individual(s) and informing the contractor of the observation; the contractor is solely responsible for determining and implementing necessary controls and corrective actions).

All verbal health and safety-related communications will be documented in project field logbook, daily reports, or other records.

5.0 Standards of Conduct

All individuals associated with this project must work injury-free and drug-free and must comply with the following standards of conduct, the HSP, and the safety requirements of CH2M HILL. Commonly accepted standards of conduct help maintain good relationships between people. They promote responsibility and self-development. Misunderstandings, frictions, and disciplinary action can be avoided by refraining from thoughtless or wrongful acts.

5.1 Standards of Conduct Violations

All individuals associated with this project are expected to behave in a professional manner. Violations of the standards of conduct would include, but not be limited to:

- Failure to perform work;
- Inefficient performance, incompetence, or neglect of work;
- Willful refusal to perform work as directed (insubordination);
- Negligence in observing safety regulations, poor housekeeping, or failure to report on-the-job injuries or unsafe conditions;
- Unexcused or excessive absence or tardiness;
- Unwillingness or inability to work in harmony with others;
- Discourtesy, irritation, friction, or other conduct that creates disharmony;
- Harassment or discrimination against another individual;
- Failure to be prepared for work by wearing the appropriate construction clothing or bringing the necessary tools; or
- Violation of any other commonly accepted reasonable rule of responsible personal conduct.

5.2 Disciplinary Actions

The Environmental Services (ES) business group employees, employees working on ES business group projects, and subcontractor employees are subject to disciplinary action for not following HSE rules and requirements. Potential disciplinary action is equally applicable to all employees including management and supervision. Disciplinary action may include denial of access to the worksite, warnings, reprimands, and other actions up to and including termination depending on the specific circumstances.

5.3 Subcontractor Safety Performance

CH2M HILL should continuously endeavor to observe subcontractors' safety performance and adherence to their plans and AHAs. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. CH2M HILL is not responsible for exhaustive observation for hazards and unsafe practices. CH2M HILL oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

5.3.1 Observed Hazard Form

When apparent non-compliance or unsafe conditions or practices are observed, notify the subcontractor's supervisor or safety representative verbally, and document using the Observed Hazard Form, included as an attachment to this HSP, and require corrective action.

If necessary, stop subcontractor's work using the Stop Work Order Form until corrective actions is implemented for observed serious hazards or conditions. Update the Observed Hazard Form to document corrective actions have been taken. The subcontractor is responsible for determining and implementing necessary controls and corrective actions.

5.3.2 Stop Work Order

CH2M HILL has the authority, as specified in the contract, and the responsibility to stop work in the event any CH2M HILL employee observes unsafe conditions or failure of the subcontractor to adhere to its safe-work practices, or observes a condition or practice that may result in a release or violation of an environmental requirement. This authority and action does not in any way relieve the subcontractor of its responsibilities for the means and methods of the work or, therefore, of any corrective actions. Failure to comply with safe work practices can be the basis for restriction or removal of the subcontractor staff from the job site, termination of the subcontract, restriction from future work, or all three.

When an apparent imminent danger is observed, immediately stop work and alert all affected individuals. Remove all affected CH2M HILL employees and subcontractor staff from the danger, notify the subcontractor's supervisor or safety representative, and do not allow work to resume until adequate corrective measures are implemented. Notify the PM, Contract Administrator (KA) and RHSM.

When repeated non-compliance or unsafe conditions are observed, notify the subcontractor's supervisor or safety representative and stop affected work by completing and delivering the Stop Work Order Form (attached to this HSP) until adequate corrective measures are implemented. Consult the KA to determine what the contract dictates for actions to pursue in event of subcontractor non-compliance including work stoppage, back charges, progress payments, removal of subcontractor manager, monetary penalties, or termination of subcontractor for cause.

5.4 Incentive Program

Each project is encouraged to implement a safety incentive program that rewards workers for exhibiting exemplary safety behaviors. Actions that qualify are those that go above and beyond what is expected. Actions that will be rewarded include spotting and correcting a hazard, bringing a hazard to the attention of your foreman, telling your foreman about an incident, coming up with a safer way to get the work done, or stopping a crew member from doing something unsafe. The program will operate throughout the project, covering all workers. The incentive program will be communicated to all employees during the project employee orientation and project safety meetings.

5.5 Reporting Unsafe Conditions/Practices

Responsibility for effective health and safety management extends to all levels of the project and requires good communication between employees, supervisors, and management. Accident prevention requires a pro-active policy on near misses, close calls, unsafe conditions, and unsafe practices. All personnel must report any situation, practice, or condition which might jeopardize the safety of our projects. All unsafe conditions or unsafe practices will be corrected immediately. CH2M HILL has zero tolerance of unsafe conditions or unsafe practices.

No employee or supervisor will be disciplined for reporting unsafe conditions or practices. Individuals involved in reporting the unsafe conditions or practices will remain anonymous.

The following reporting procedures will be followed by all project employees:

- Upon detection of any unsafe condition or practice, the responsible employee will attempt to safely correct the condition;
- The unsafe condition or practice will be brought to the attention of the worker's direct supervisor, unless the unsafe condition or practice involves the employee's direct supervisor. If so, the SC needs to be notified at once by the responsible employee;
- Either the responsible employee or responsible employee's direct supervisor is responsible for immediately reporting the unsafe condition or practice to the SC;
- The SC will act promptly to correct the unsafe condition or practice; and
- Details of the incident or situation will be recorded by the SC in the field logbook or use the Observed Hazard Form if subcontractor was involved.

6.0 Safety Planning and Change Management

6.1 Daily Safety Meetings and Pre-Task Safety Plans

Daily safety meetings are to be held with all project personnel in attendance to review the hazards posed and required HSE procedures and AHAs that apply for each day's project activities. The Pre-Task Safety Plans (PTSPs) serve the same purpose as these general assembly safety meetings, but the PTSPs are held between the crew supervisor and their work crews to focus on those hazards posed to individual work crews.

At the start of each day's activities, the crew supervisor completes the PTSP, provided as an attachment to this HSP, with input from the work crew, during their daily safety meeting. The day's tasks, personnel, tools and equipment that will be used to perform these tasks are listed, along with the hazards posed and required HSE procedures, as identified in the HSP and AHA. The use of PTSPs promotes worker participation in the hazard recognition and control process while reinforcing the task-specific hazard and required HSE procedures with the crew each day.

6.2 Change Management

This HSP addresses all known activities and associated hazards. As work progresses, if significant changes are identified which could affect health and safety at the site, coordinate with the RHSM to determine whether a HSP update is necessary.

The following are examples of changes that may require a revision to the plan:

- Change in CH2M HILL staff;
- New subcontractor to perform work;
- New chemicals brought to site for use;
- Change in scope or addition of new tasks;
- Change in contaminants of concern (COCs) or change in concentrations of COCs; and
- New hazards or hazards not previously identified that are not addressed in this HSP.

6.3 Agency Inspection Guidance

(Reference CH2M HILL SOP HSE-201, *Agency Inspections and Communications*)

Agency inspections (e.g., OSHA, EPA, other regulatory agencies) are on the rise. CH2M HILL implements safety and environmental programs in order to ensure safety to workers, the public, and the environment. This plan addresses things like labeling containers, completing the hazard communication training using the attachments to this HSP, listing training requirements and PPE requirements, and addressing project-specific hazards. Field personnel need to contact the RHSM to update this plan if hazards are encountered that are not addressed.

Following is some pertinent information regarding OSHA inspections in 2011:

- The number of OSHA inspectors increased by 130;
- A goal has been set to conduct 44,000 workplace inspections which is up from 36,000;
- The definition for "Repeat Violations" will encompass the past 5 years versus 3 years;
- OSHA directors can only reduce fines by a maximum of 30%;
- Some fines will be increased between $3,000 and $4,000 per violation;

- Proposed legislature - Serious fines raised from $7,000 to $12,000; and
- Proposed legislature - Willful fines from $70,000 to $250,000.

SOP HSE-201 addresses agency inspections in detail, and the attached **Target Zero Bulletin on Agency Inspections** provides a good summary of the inspection process and what to do if an agency such as OSHA or EPA shows up at the site. It is critical immediate notification or the RHSM if an inspector arrives (and EM if it is environmental-related); they can help facilitate and make additional notifications.

Please either post the Target Zero Bulletin at your field trailer or keep it with your Health and Safety Plan/Environmental Plan; make it a topic at a safety meeting and keep it readily available in the event of an inspection.

7.0 Project Hazard Analysis

A health and safety risk analysis (Table 1) has been performed for each task. In the order listed below, the RHSM considers the various methods for mitigating the hazards. Employees are trained on this hierarchy of controls during their hazardous waste training and reminded of them throughout the execution of projects:

- Elimination of the hazards (use remote sampling methodology to avoid going into a confined space);
- Substitution (reduce exposure to vapors by using of a geoprobe instead of test pitting);
- Engineering controls (ventilate a confined space to improve air quality);
- Warnings (establish exclusion zones to keep untrained people away from hazardous waste work);
- Administrative controls (implement a work-rest schedule to reduce chance of heat stress); or
- Use of PPE (use of respirators when action levels are exceeded).

The hazard controls and safe work practices are summarized in the following sections of this HSP:

- General hazards and controls;
- Project-specific hazards and controls;
- Physical hazards and controls;
- Biological hazards and controls; and
- Contaminants of concern.

7.1 Activity Hazard Analysis

An AHA must be developed for each CH2M HILL job activity. The AHA shall define the work tasks required to perform each activity, along with potential HSE hazards and recommended control measures for each hazard. In addition, a listing of the equipment to be used to perform the activity, inspection requirements to be performed and training requirements for the safe operation of the equipment listed must be identified. Workers are briefed on the AHA before performing the work and their input is solicited prior, during, and after the performance of work to further identify the hazards posed and control measures required. The AHA shall identify the work tasks required to perform each activity, along with potential HSE hazards and recommended control measures for each hazard.

The following hazard controls and applicable CH2M HILL core standards and SOPs should be used as a basis for preparing AHAs.

AHAs prepared for CH2M HILL activities are included as an attachment to this HSP.

7.2 Subcontractor Activity Hazard Analysis

CH2M HILL subcontractors are required to provide AHAs specific to their scope of work on the project for acceptance by CH2M HILL. Each subcontractor shall submit AHAs for their field activities, as defined in their scope of work, along with their project-specific safety plan and procedures. Additions or changes in field activities, equipment, tools, or material used to perform work or hazards not addressed in existing AHAs requires either a new AHA to be prepared or an existing AHA to be revised.

Table 1 – General Activity Hazard Analysis

Potential Hazard	Monitoring Well & Pore Sample Point Installation/ DPT Drilling	Surveying	Utility Locating	Groundwater Sampling & Pore Sampling
Biological Hazards	X	X	X	X
Chemical Hazard	X			X
Compressed Gas Cylinders	X			X
Drilling	X			
Drum Handling	X			
Drum Sampling	X			X
Electrical Safety	X			
Field Vehicles	X	X	X	X
Fire Prevention	X	X	X	X
Forklifts	X			X
Groundwater/Pore Sampling Hazards				X
Hand & Power Tools	X	X		X
Knife Use	X	X	X	X
Lockout/Tagout	X			X
Manual Lifting	X	X	X	X
Noise	X			X
Pressurized Lines/ Equipment	X			
Pressure Washing Equipment/ Decontamination	X			
Temperature Extremes	X	X	X	X
Ultraviolet Light exposure (sunburn)	X	X	X	X
Utilities (underground/overhead)	X		X	
Visible Lighting	X	X	X	X
Working Above/Near Water				X
Work Alone	X	X	X	X
Vinyl Chloride	X			X

8.0 General Hazards and Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. It is a summarized list of requirements. Always consult the appropriate CH2M HILL SOP to ensure all requirements are implemented.

8.1 Bloodborne Pathogens

(Reference CH2M HILL SOP HSE-202, *Bloodborne Pathogens*)

Exposure to bloodborne pathogens may occur when rendering first aid or cardiopulmonary resuscitation (CPR), or when coming into contact with landfill waste or waste streams containing potentially infectious material (PIM).

Employees trained in first-aid/CPR or those exposed to PIM must complete CH2M HILL's 1-hour bloodborne pathogens computer-based training module annually. When performing first-aid/CPR the following shall apply:

- Observe universal precautions to prevent contact with blood or other PIMs. Where differentiation between body fluid types is difficult or impossible, consider all body fluids to be potentially infectious materials;
- Always wash your hands and face with soap and running water after contacting PIMs. If washing facilities are unavailable, use an antiseptic cleanser with clean paper towels or moist towelettes; and
- If necessary, decontaminate all potentially contaminated equipment and surfaces with chlorine bleach as soon as possible. Use one part chlorine bleach (5.25 percent sodium hypochlorite solution) diluted with 10 parts water for decontaminating equipment or surfaces after initially removing blood or other PIMs. Remove contaminated PPE as soon as possible before leaving a work area.

CH2M HILL will provide exposed employees with a confidential medical examination should an exposure to PIM occur. This examination includes the following procedures:

- Documenting the exposure;
- Testing the exposed employee's and the source individual's blood (with consent); and
- Administering post-exposure prophylaxis.

8.2 Chemical Storage

The following are general guidelines for storing chemicals and other hazardous materials:

- Keep acids away from bases;
- Keep oxidizers (nitric acid, nitrates, peroxides, chlorates) and organics away from inorganic reducing agents (metals);
- Keep flammables and corrosives in appropriate storage cabinets;
- Do not store paper or other combustibles near flammables;
- Use secondary containment and lipped shelving that is secured; and
- Have a fire suppression system available.

8.2.1 Storage of Flammable/Combustible Liquids

- Only approved containers and portable tanks shall be used for storage and handling of flammable and combustible liquids.
- Approved safety cans shall be used for the handling and use of flammable liquids in quantities of 5 gallons (22.7 liters) or less. Do not use plastic gas cans.
- For quantities of 1 gallon (4.5 liters) or less, the original container may be used for storage and use of flammable liquids.
- Flammable or combustible liquids shall not be stored in areas used for stairways or normally used for the passage of people.

8.2.2 Indoor Storage of Flammable/Combustible Liquids

- No more than 25 gallons (113.7 liters) of flammable or combustible liquids shall be stored in a room outside of an approved storage cabinet.
- Quantities of flammable and combustible liquids in excess of 25 gallons (113.7 liters) shall be stored in an acceptable or approved cabinet.
- Cabinets shall be conspicuously lettered: "FLAMMABLE: KEEP FIRE AWAY."
- Not more than 60 gallons (272.8 liters) of flammable or 120 gallons (545.5 liters) of combustible liquids shall be stored in any one storage cabinet. Not more than three such cabinets may be located in a single storage area.

8.2.3 Outside Storage of Flammable/Combustible Liquids

- Storage of containers (not more than 60 gallons [272.8 liters] each) shall not exceed 1,100 gallons (5000 liters) in any one area. No area shall be within 20 feet (6.1 meters) of any building.
- Storage areas shall be graded to divert spills away from buildings and surrounded by an earthen dike.
- Storage areas may not be located near a storm drain. Overflow and spills must be diverted away from storm drains or surface waters.
- Storage areas shall be free from weeds, debris, and other combustible materials.
- Outdoor portable tanks shall be provided with emergency vent devices and shall not be closer than 20 feet (6.1 meters) to any building.
- Signs indicating no smoking shall be posted around the storage area.

8.2.4 Storage of Hazardous Waste

- All facilities storing ignitable and combustible liquids and hazardous wastes must be designed, constructed, maintained, and operated to minimize the possibility of a fire, explosion, or any release of hazardous constituents.
- Flammable wastes should be stored more than 50 feet from the property line.

8.2.5 Storage of Chemical Injection Chemicals/Materials

When chemical injection remediation technologies are being used at a site, the following storage guidelines must be followed:

- Some injection chemicals, such as strong oxidizers, may have stringent storage requirements per local or National Fire Codes. Verify that appropriate storage provisions are in place prior to starting work.

NOTE: Counties and cities may have requirements specific to storing these chemicals. Also, storage and use of certain chemicals such as potassium permanganate and hydrogen peroxide may be subject to the new Chemical Facility Anti-Terrorism Standards of the Department of Homeland Security – the applicability depends on the chemical, quantity/concentration, and type of facility. Please contact the project Environmental Manager to determine whether chemicals are subject to these standards.

- Injection chemicals must be stored in a designated, secured area with spill prevention capabilities. Review MSDS or other information to determine potential incompatible materials. Incompatible materials shall not be stored together. Ensure all containers are labeled.

8.3 Driving Safety

Follow the guidelines below when operating a vehicle:

- Refrain from using a cellular phone while driving. Pull off the road, put the vehicle in park and turn on flashers before talking on a cellular phone;
- Never operate a personal digital assistant (PDA), or other device with e-mail, internet, or text messaging function while driving a vehicle;
- Obey speed limits; be aware of blind spots or other hazards associated with low visibility. Practice defensive driving techniques, such as leaving plenty of room between your vehicle and the one ahead of you;
- Do no drive while drowsy. Drowsiness can occur at any time, but is most likely after 18 hours or more without sleep;
- Maintain focus on driving. Eating, drinking, smoking, adjusting controls can divert attention from the road. Take the time to park and perform these tasks when parked rather than while driving; and
- Ensure vehicle drivers are familiar with the safe operation of vehicles of the type and size to be operated. Large vehicles such as full size vans and pick-ups have different vision challenges and handling characteristics than smaller vehicles.

8.4 Electrical Safety

(Reference CH2M HILL SOP HSE-206, *Electrical Safety*)

Below are the hazard controls and safe work practices to follow when using electrical tools, extension cords, and/or other electrical-powered equipment or when exposed to electrical hazards. Ensure the requirements of the referenced SOP are followed:

- Only qualified personnel are permitted to work on unprotected energized electrical systems;
- Only authorized personnel are permitted to enter high-voltage areas;
- CH2M HILL employees who might from time to time work in an environment influenced by the presence of electrical energy must complete Awareness Level Electrical Safety Training located on the CH2M HILL Virtual Office;
- Do not tamper with electrical wiring and equipment unless qualified to do so. All electrical wiring and equipment must be considered energized until lockout/tagout procedures are implemented;
- Inspect electrical equipment, power tools, and extension cords for damage prior to use. Do not use defective electrical equipment, remove from service;
- CH2M HILL has selected Ground Fault Circuit Interrupters (GFCIs) as the standard method for protecting employees from the hazards associated with electric shock;

  - GFCIs shall be used on all 120-volt, single phase 15 and 20-amphere receptacle outlets which are not part of the permanent wiring of the building or structure.
- An assured equipment grounding conductor program may be required under the following scenarios:
  - GFCIs cannot be utilized;
  - Client requires such a program to be implemented; or
  - Business group decides to implement program in addition to GFCI protection.
- Extension cords must be equipped with third-wire grounding. Cords passing through work areas must be covered, elevated or protected from damage. Cords should not be routed through doorways unless protected from pinching. Cords should not be fastened with staples, hung from nails, or suspended with wire;
- Electrical power tools and equipment must be effectively grounded or double-insulated and Underwriters Laboratory (UL) approved;
- Operate and maintain electric power tools and equipment according to manufacturers' instructions;
- Maintain safe clearance distances between overhead power lines and any electrical conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet (3 meters) from overhead power lines for voltages of 50 kV or less, and 10 feet (3 meters) plus 0.4 inches (1.0 cm) for every 1 kV over 50 kV;
- Temporary lights shall not be suspended by their electric cord unless designed for suspension. Lights shall be protected from accidental contact or breakage; and
- Protect all electrical equipment, tools, switches, and outlets from environmental elements.

8.5 Field Vehicles

- Field vehicles may be personal vehicles, rental vehicles, fleet vehicles, or project vehicles.
- Maintain a first aid kit, bloodborne pathogen kit, and fire extinguisher in the field vehicle at all times.
- Utilize a rotary beacon on vehicle if working adjacent to active roadway.
- Familiarize yourself with rental vehicle features prior to operating the vehicle:
  - Vision Fields and Blind Spots
  - Vehicle Size
  - Mirror adjustments
  - Seat adjustments
  - Cruise control features, if offered
  - Pre-program radio stations and Global Positioning System (GPS), if equipped
- Always wear seatbelt while operating vehicle.
- Adjust headrest to proper position.
- Tie down loose items if utilizing a van or pick-up truck.
- Close car doors slowly and carefully. Fingers can get pinched in doors.
- Park vehicle in a location where it can be accessed easily in the event of an emergency. If not possible, carry a phone.

- Have a designated place for storing the field vehicle keys when not in use.
- Ensure back-up alarms are functioning, if equipped. Before backing a vehicle, take a walk around the vehicle to identify obstructions or hazards. Use a spotter when necessary to back into or out of an area.
- See the Vehicle Accident Guidance attached to this HSP, if a vehicle incident is experienced in a rental or fleet vehicle.

8.6 Fire Prevention

(Reference CH2M HILL SOP HSE-403, *Hazardous Material Handling*)

Follow the fire prevention and control procedures listed below.

8.6.1 Fire Extinguishers and General Fire Prevention Practices

- Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet (30.5 meters). When 5 gallons (19 liters) or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet (15.2 meters). Extinguishers must:
  - be maintained in a fully charged and operable condition;
  - be visually inspected each month; and
  - undergo a maintenance check each year.
- The area in front of extinguishers must be kept clear.
- Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations.
- Combustible materials stored outside should be at least 10 feet (3 meters) from any building.
- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Keep areas neat. Housekeeping is important.

8.6.2 Dispensing of Flammable/Combustible Liquids

- Areas in which flammable or combustible liquids are dispensed in quantities greater than 5 gallons (22.7 liters) (shall be separated from other operations by at least 25 feet (7.6 meters).
- Drainage away from storm drains or surface waters or other means of containment shall be provided to control spills.
- Adequate natural or mechanical ventilation shall be provided to maintain the concentration of flammable vapor at or below 10 percent of the lower flammable limit.
- Dispensing of flammable liquids from one container to another shall be done only when containers are electrically interconnected (bonded).
- Dispensing flammable or combustible liquids by means of air pressure on the container or portable tanks is prohibited.
- Dispensing devices and nozzles for flammable liquids shall be of an approved type.

8.7 General Practices and Housekeeping

The following are general requirements applicable to all portions of the work:

- Site work should be performed during daylight hours whenever possible;
- Good housekeeping must be maintained at all times in all project work areas;
- Common paths of travel should be established and kept free from the accumulation of materials;
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions;
- Provide slip-resistant surfaces, ropes, or other devices to be used;
- Specific areas should be designated for the proper storage of materials;
- Tools, equipment, materials, and supplies shall be stored in an orderly manner;
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area;
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals;
- All spills shall be quickly cleaned up; oil and grease shall be cleaned from walking and working surfaces;
- Review the safety requirements of each job you are assigned to with your supervisor. You are not expected to perform a job that may result in injury or illness to yourself or to others;
- Familiarize yourself with, understand, and follow jobsite emergency procedures;
- Do not fight or horseplay while conducting the firm's business;
- Do not use or possess firearms or other weapons while conducting the firm's business;
- Report unsafe conditions or unsafe acts to your supervisor immediately;
- Report emergencies, occupational illnesses, injuries, vehicle accidents, and near misses immediately;
- Do not remove or make ineffective safeguards or safety devices attached to any piece of equipment;
- Report unsafe equipment, defective or frayed electrical cords, and unguarded machinery to your supervisor;
- Shut down and lock out machinery and equipment before cleaning, adjustment, or repair. Do not lubricate or repair moving parts of machinery while the parts are in motion;
- Do not run in the workplace;
- When ascending or descending stairways, use the handrail and take one step at a time;
- Do not apply compressed air to any person or clothing;
- Do not wear steel taps or shoes with metal exposed to the sole at any CH2M HILL project location;
- Do not wear finger rings, loose clothing, wristwatches, and other loose accessories when within arm's reach of moving machinery;
- Remove waste and debris from the workplace and dispose of in accordance with federal, state, and local regulations;

- Note the correct way to lift heavy objects (secure footing, firm grip, straight back, lift with legs), and get help if needed. Use mechanical lifting devices whenever possible; and
- Check the work area to determine what problems or hazards may exist.

8.8 Hazard Communication

(Reference CH2M HILL SOPs HSE-107, *Hazard Communication* and HSE-403, *Hazardous Material Handling*)

The hazard communication coordinator is to perform the following:

- Complete an inventory of chemicals brought on site by CH2M HILL using the chemical inventory form included as an attachment to this HSP;
- Confirm that an inventory of chemicals brought on site by CH2M HILL subcontractors is available;
- Request or confirm locations of material safety data sheets (MSDSs) from the client, contractors, and subcontractors for chemicals to which CH2M HILL employees potentially are exposed;
- Before or as the chemicals arrive on site, obtain an MSDS for each hazardous chemical and include on the chemical inventory sheet (attached to this HSP) and add the MSDS to the MSDS attachment section of this HSP;
- Label chemical containers with the identity of the chemical and with hazard warnings, and store properly;
- Give employees required chemical-specific HAZCOM training using the chemical-specific training form included as an attachment to this HSP; and
- Store all materials properly, giving consideration to compatibility, quantity limits, secondary containment, fire prevention, and environmental conditions.

8.9 Knife Use

Open-bladed knives (for example, box cutters, utility knives, pocket knives, machetes, and multi-purpose tools with fixed blades such as a Leatherman™) are prohibited at worksites except where the following three conditions are met:

- The open-bladed knife is determined to be the best tool for the job;
- An approved Activity Hazard Analysis (AHA) or written procedure is in place that covers the necessary safety precautions (work practices, PPE, and training); and
- Knife users have been trained and follow the AHA.

8.10 Lighting

Lighting shall be evaluated when conducting work inside buildings, confined spaces, or other areas/instances where supplemental light may be needed (e.g., work before sunrise or after sunset). A light meter can be used to evaluate the adequacy of lighting. The following are common requirements for lighting and the conditions/type of work being performed:

- While work is in progress outside construction areas shall have at least 33 lux (lx);
- Construction work conducted inside buildings should be provided with at least 55 lux light;
- The means of egress shall be illuminated with emergency and non-emergency lighting to provide a minimum 11 lx measured at the floor. Egress illumination shall be arranged so that the failure of any single lighting unit, including the burning out of an electric bulb will not leave any area in total darkness.

8.11 Manual Lifting

(Reference CH2M HILL SOP HSE-112, *Manual Lifting*)

Back injuries are the leading cause of disabling work and most back injuries are the result of improper lifting techniques or overexertion. Use the following to mitigate the hazards associated with lifting:

- When possible, the task should be modified to minimize manual lifting hazards;
- Lifting of loads weighing more than 40 pounds (18 kilograms) shall be evaluated by the SC using the Lifting Evaluation Form contained in SOP HSE-112;
- Using mechanical lifting devices is the preferred means of lifting heavy objects such as forklifts; cranes, hoists, and rigging; hand trucks; and trolleys;
- Personnel shall seek assistance when performing manual lifting tasks that appear beyond their physical capabilities;
- In general, the following steps must be practiced when planning and performing manual lifts: Assess the situation before you lift; ensure good lifting and body positioning practices; ensure good carrying and setting down practices; and
- All CH2M HILL workers must have training in proper manual lifting training either through the New Employee Orientation or through Manual Lifting module located on the VO.

8.12 Personal Hygiene

Good hygiene is essential for personal health and to reduce the potential of cross-contamination when working on a hazardous waste site. Implement the following:

- Keep hands away from nose, mouth, and eyes during work;
- Keep areas of broken skin (chapped, burned, etc.) covered; and
- Wash hands with soap and water prior to eating, smoking, or applying cosmetics.

8.13 Shipping and Transportation of Hazardous Materials

(Reference CH2M HILL SOP HSE-417, *Hazardous Materials Transportation*)

The U.S. Department of Transportation (DOT) has specific regulations governing shipping of hazardous materials (also called dangerous goods). Chemicals brought to the site might be defined as hazardous materials by the U.S DOT. Hazardous wastes that may be shipped offsite are also defined as hazardous materials by U.S. DOT. Other wastes may also be U.S. DOT hazardous materials. To confirm whether a material or a waste is a U.S. DOT hazardous material, check with the ESBG Waste Coordinator (Lisa Schwan/ATL), the project EM, or the CH2M HILL Dangerous Goods Shipping Coordinators (John Blasco/BAO or Rob Strehlow/MKW).

All staff who affect shipment of hazardous materials, including receiving hazardous materials, preparing profiles or manifests, packaging hazardous wastes, labeling, or transporting hazardous materials by road, are called HazMat employees (note CH2M HILL cannot transport hazardous wastes by public road). HazMat employees must receive CH2M HILL online training in shipping dangerous goods. CH2M HILL's online Dangerous Goods Shipping course can be found on the CH2M HILL HSSE website.

All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. If the material is a product that is being shipped (e.g., calibration gas), use the HazMat ShipRight tool on the CH2M HILL virtual office

(under Company Resources – Online Shipping). Contact the Dangerous Goods Shipping coordinators, the ESBG Waste Coordinator or the project EM for additional information.

49 CFR 172 requires that all hazmat employees be aware of potential transportation security concerns. Hazardous materials security is addressed in CH2M HILL's Hazardous Materials SOP (HSE-403). The following points are provided as an overview of security measures to increase awareness of this important matter:

- It is essential that each employee understand the security risks involved with transporting hazardous materials;
- All transporters of hazardous materials must be prequalified by a Contracts Administrator who evaluate the carrier's safety rating, security measures, and employee screening procedures;
- When shipping hazardous materials, check driver credentials and ask about shipping details;
- When receiving a hazardous materials shipment, inspect packages for signs of tampering or damage to the contents. Verify the drivers and company information on the form with the driver; and
- If there is suspicious or unusual behavior (e.g., driver without credentials, evasive answers) or any discrepancies identified, do not offer or accept the shipment, and immediately notify the project manager or the RHSM.

Employees responsible for shipping hazard materials must also review the CH2M HILL Transportation Security Plan (HSE-417 Appendix A).

8.14 Substance Abuse

(Reference CH2M HILL SOP HSE-105, *Drug-Free Workplace*)

Employees who work under the influence of controlled substances, drugs, or alcohol may prove to be dangerous or otherwise harmful to themselves, other employees, clients, the company, the company's assets and interests, or the public. CH2M HILL does not tolerate illegal drug use, or any use of drugs, controlled substances, or alcohol that impairs an employee's work performance or behavior.

Prohibitions onsite include:

- Use or possession of intoxicating beverages while performing CH2M HILL work;
- Abuse of prescription or nonprescription drugs;
- Use or possession of illegal drugs or drugs obtained illegally;
- Sale, purchase, or transfer of legal, illegal or illegally obtained drugs; and
- Arrival at work under the influence of legal or illegal drugs or alcohol.

Drug and/or alcohol testing is applicable under CH2M HILL Constructors, Inc. and munitions response projects performed in the United States. In addition, employees may be required to submit to drug and/or alcohol testing as required by clients. When required, this testing is performed in accordance with SOP HSE-105, Drug-Free Workplace. Employees who are enrolled in drug or alcohol testing are required to complete annual training located on the CH2M HILL Virtual Office (VO).

9.0 Project-Specific Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the work or the particular hazard. Each person onsite is required to abide by the hazard controls. Always consult the appropriate CH2M HILL SOP to ensure all requirements are implemented. CH2M HILL employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the RHSM for clarification.

9.1 Compressed Gas Cylinders

(Reference CH2M HILL SOP HSE-403, *Hazardous Materials Handling*)

Below are the hazard controls and safe work practices to follow when working around or using compressed gas cylinders. Ensure the requirements in the referenced SOP are followed.

- Cylinders and pressure-controlling apparatus shall be inspected for defects and leakage prior to use. Damaged or defective items shall not be used. If a cylinder is found to be defective, the gas distributor shall be notified and subsequent instructions followed. If a leak should develop at a fuse plug or other safety device, the cylinder shall be removed from the work area.
- Cylinders shall be labeled with the identity of the contents. Cylinders not labeled shall be sent back to the cylinder distributor. The color of the cylinder shall not be used exclusively to identify cylinder contents.
- Valve caps must be in place when cylinders are transported, moved, or stored.
- Cylinders must be secured in an upright position at all times.
- Cylinder valves must be closed when cylinders are not being used and when cylinders are being moved.
- Cylinders must be secured on a cradle, basket, or pallet when hoisted; they may not be hoisted by choker slings.
- Eye protection (safety glasses or goggles) shall be worn when using cylinders.
- Cylinders must be shielded from welding and cutting operations and positioned to avoid being struck or knocked over; contacting electrical circuits; or exposed to extreme heat sources.
- Cylinders inside buildings shall be stored in dry, well-ventilated locations at least 20 feet (6.1 meters) from highly combustible materials. Cylinders should be stored in definitely assigned places away from elevators, stairs, or gangways. Assigned storage areas shall be located where cylinders will not be knocked over or damaged.
- Oxygen cylinders in storage shall be separated from fuel gas cylinders or combustible materials by a minimum of 20 feet (6.1 meters) or by a noncombustible barrier at least 5 feet (1.5 meters) high, having a fire resistance rating of at least 0.5 hour.
- Signs indicating no smoking shall be provided for storage areas containing flammable gas cylinders.
- Complete the self-assessment checklist for compressed gas cylinders are being used.

9.2 Drilling Safety

(Reference CH2M HILL SOP HSE-204, *Drilling*)

Below are the hazard controls and safe work practices to follow when working around or performing drilling. Ensure the requirements in the referenced SOP are followed.

- The drill rig is not to be operated in inclement weather.
- The driller is to verify that the rig is properly leveled and stabilized before raising the mast.
- Personnel should be cleared from the sides and rear of the rig before the mast is raised.
- The driller is not to drive the rig with the mast in the raised position.
- The driller must check for overhead power lines before raising the mast. Maintain a minimum distance of 10 feet (3 meters) between mast and overhead lines (<50 kV) and an additional 0.4 inches for every 1 kV over 50kV. Verify the voltage of nearby overhead powerlines to determine the minimum distance.
- If the project site is suspected of munitions or explosives of concern (MEC) contamination, requirements of the *Explosives Usage and Munitions Response (MR)* SOP HSE-610 shall be followed. MECs include unexploded ordnance (UXO), discarded military munitions, materials that present a potential explosive hazard, chemical warfare materials, munitions constituents, and contaminated soil or groundwater. "Down-hole" avoidance support may be required to prevent accidental contact with UXO. Safety requirements will be based on the risk assessment identified within the MR (safety) ORE (Opportunity Risk Evaluation).
- Personnel should stand clear before rig startup.
- The driller is to verify that the rig is in neutral when the operator is not at the controls.
- Become familiar with the hazards associated with the drilling method used (cable tool, air rotary, hollow-stem auger, etc.).
- Do not wear loose-fitting clothing, watches, etc., that could get caught in moving parts.
- Do not smoke or permit other spark-producing equipment around the drill rig.
- The drill rig must be equipped with a kill wire or switch, and personnel are to be informed of its location.
- Be aware and stand clear of heavy objects that are hoisted overhead.
- The driller is to verify that the rig is properly maintained in accordance with the drilling company's maintenance program.
- The driller is to verify that all machine guards are in place while the rig is in operation.
- The driller is responsible for housekeeping (maintaining a clean work area).
- The drill rig should be equipped with at least one fire extinguisher.
- If the drill rig comes into contact with electrical wires and becomes electrically energized, do not touch any part of the rig or any person in contact with the rig, and stay as far away as possible. Notify emergency personnel immediately.
- Use the drilling self-assessment checklist attached to this HSP to evaluate drilling operations.

9.3 Drum and Portable Tank Handling

Below are the hazard controls and safe work practices to follow when overseeing the movement of drums or when handling drums:

- Ensure that personnel are trained in proper lifting and moving techniques to prevent back injuries;
- Ensure drum or tank bungs and lids are secured and are labeled prior to moving;
- Ensure that drums and tanks remain covered except when removing or adding material or waste. Covers and/or lids will be properly secured at the end of each workday;
- Provide equipment to keep the operator removed from the drums to lessen the likelihood of injury. Such equipment might include: a drum grappler attached to a hydraulic excavator; a small front-end loader, which can be either loaded manually or equipped with a bucket sling; a rough terrain forklift; Roller conveyor equipped with solid rollers; drum carts designed specifically for drum handling;
- Make sure the vehicle selected has sufficient rated load capacity to handle the anticipated loads, and make sure the vehicle can operate smoothly on the available road surface;
- Ensure there are appropriately designed Plexiglas cab shields on loaders, backhoes, etc., when handling drums containing potentially explosive materials;
- Equipment cabs should be supplied with fire extinguishers, and should be air-conditioned to increase operator efficiency;
- Supply operators with appropriate respiratory protective equipment when needed;
- Ensure that drums are secure and are not in the operator's view of the roadway;
- Prior to handling, all personnel should be warned about hazards of handling;
- Before moving anything, determine the most appropriate sequence in which the various drums, portable tanks, and other containers should be moved (e.g. small containers may have to be removed first to permit heavy equipment to enter and move the drums;
- Overpack drums and an adequate volume of absorbent should be kept near areas where minor spills may occur;
- Use containers or overpacks that are compatible with the waste or materials;
- Drums containing liquids or hazardous waste will be provided with secondary containment and may not be located near a storm water inlet or conveyance;
- Allow enough aisle space between drum pallets and between drums and other equipment that the drums can be easily accessed (at least 2 to 3 feet) by fire control equipment and similar equipment.; and
- Make sure that a spill kit is available in drum or tank storage areas (or where liquids are transferred from one vessel to another).

9.4 Drum Sampling Safety

Personnel are permitted to handle and/or sample drums containing certain types of waste (drilling waste, investigation-derived waste, waste from known sources) only. Handling or sampling drums with unknown contents requires a plan revision or amendment approved by the RHSM. The following control measures will be taken when sampling drums:

- Minimize transportation of drums;

- Sample only labeled drums or drums from a known waste stream;
- Do not sample bulging or swollen drums. Contact the RHSM;
- If drums contain, or potentially contain, flammable materials, use non-sparking tools to open;
- Use the proper tools to open and seal drums;
- Reseal bung holes or plugs whenever possible;
- Avoid mixing incompatible drum contents;
- Sample drums without leaning over the drum opening;
- Transfer/sample the content of drums using a method that minimizes contact with material;
- Use the PPE and perform air monitoring as specified in the PPE and Site Monitoring sections of this HSP;
- Take precautions to prevent contaminated media from contacting the floor or ground, such as having plastic under the sampling area, having a spill kit accessible during sampling activities; and
- If transferring/sampling drums containing flammable or combustible liquids, drums and liquid transfer equipment should be grounded and bonded to reduce the potential of a static discharge.

9.5 Forklift Operations

(Reference CH2M HILL, SOP HSE-309, *Forklifts*)

Below are the hazard controls and safe work practices to follow when working around or operating forklifts. Ensure the requirements in the referenced SOP are followed.

- A rated lifting capacity must be posted in a location readily visible to the operator.
- A forklift truck must not be used to elevate employees unless a platform with guardrails, a back guard, and a kill switch is provided on the vehicle. When guardrails are not possible, fall arrest protection is required.
- The subcontractor operating the forklift must post and enforce a set of operating rules for forklift trucks.
- Only certified forklift operators shall operate forklifts.
- Stunt driving and horseplay are prohibited.
- Employees must not ride on the forks.
- Employees must never be permitted under the forks (unless forks are blocked).
- The driver must inspect the forklift once a shift and document this inspection.
- The operator must look in the direction of travel and must not move the vehicle until all persons are clear of the vehicle.
- Forks must be carried as low as possible.
- The operator must lower the forks, shut off the engine, and set the brakes (or block the wheels) before leaving the forklift operator's position unless maintenance or safety inspections require the forklift to be running.
- Trucks must be blocked and have brakes set when forklifts are driven onto their beds.
- Extreme care must be taken when tilting elevated loads.

- Every forklift must have operable brakes capable of safely stopping it when fully loaded.
- Forklifts must have parking brakes and an operable horn.
- When the operator is exposed to possible falling objects, industrial trucks must be equipped with overhead protection (canopy).
- If using certified CH2M HILL forklift operators—forklifts must be inspected and documented daily using the forklift inspection form.

9.6 Groundwater Sampling/Water Level Measurements

Below are the hazard controls and safe work practices to follow when personnel or subcontractors are performing groundwater sampling and/or water level measurements.

- Full coolers are heavy. Plan in advance to have two people available at the end of the sampling effort to load full coolers into vehicles. If two people won't be available use several smaller coolers instead of fewer large ones.
- Wear the appropriate PPE when sampling, including safety glasses, nitrile gloves, and steel toe boots (see PPE section of this HSP).
- Monitor headspace of wells prior to sampling to minimize any vapor inhalation (refer to the "Site Monitoring" section of this HSP).
- Use caution when opening well lids. Wells may contain poisonous spiders and hornet or wasp nests.
- Use the appropriate lifting procedures (see CH2M HILL SOP HSE-112) when unloading equipment and sampling at each well.
- Avoid sharp edges on well casings.
- If dermal contact occurs with groundwater or the acid used in sample preservation, immediately wash all affected skin thoroughly with soap and water.
- Avoid eating and drinking on site and during sampling.
- Use ear plugs during sampling if sampling involves a generator.
- Containerize all purge water and transport to the appropriate storage area.
- Use two people to transport full coolers/containers whenever possible. If two people are not available use a dolly to move coolers. If the coolers weigh more than 40 pounds Attachment 1 of the HSE-112, *Manual Lifting,* shall be completed by the SC. If the coolers weigh more than 50 pounds they should never be lifted by one person.

9.7 Hand and Power Tools

(Reference CH2M HILL, SOP HSE-210, *Hand and Power Tools*)

Below are the hazard controls and safe work practices to follow when personnel or subcontractors are using hand and power tools. Ensure the requirements in the referenced SOP are followed:

- Tools shall be inspected prior to use and damaged tools will be tagged and removed from service;
- Hand tools will be used for their intended use and operated in accordance with manufacturer's instructions and design limitations;
- Maintain all hand and power tools in a safe condition;

- Use PPE (such as gloves, safety glasses, earplugs, and face shields) when exposed to a hazard from a tool;
- Do not carry or lower a power tool by its cord or hose;
- Portable power tools will be plugged into GFCI protected outlets;
- Portable power tools will be Underwriters Laboratories (UL) listed and have a three-wire grounded plug or be double insulated;
- Disconnect tools from energy sources when they are not in use, before servicing and cleaning them, and when changing accessories (such as blades, bits, and cutters);
- Safety guards on tools must remain installed while the tool is in use and must be promptly replaced after repair or maintenance has been performed;
- Store tools properly in a place where they will not be damaged or come in contact with hazardous materials;
- If a cordless tool is connected to its recharge unit, both pieces of equipment must conform strictly with electrical standards and manufacturer's specifications;
- Tools used in an explosive environment must be rated for work in that environment (that is, intrinsically safe, spark-proof, etc.); and
- Working with manual and pistol-grip hand tools may involve highly repetitive movement, extended elevation, constrained postures, and/or awkward positioning of body members (for example, hand, wrist, arm, shoulder, neck, etc.). Consider alternative tool designs, improved posture, the selection of appropriate materials, changing work organization, and sequencing to prevent muscular, skeletal, repetitive motion, and cumulative trauma stressors.

Machine Guarding

- Ensure that all machine guards are in place to prevent contact with drive lines, belts, chains, pinch points or any other sources of mechanical injury.
- Unplugging jammed equipment will only be performed when equipment has been shut down, all sources of energy have been isolated and equipment has been locked/tagged and tested.
- Maintenance and repair of equipment that results in the removal of guards or would otherwise put anyone at risk requires lockout of that equipment prior to work.

9.8 Haul Trucks

Below are the hazard controls and safe work practices to follow when working around or operating haul trucks:

- Haul truck operators should be familiar with their equipment and inspect all equipment before use;
- Haul truck operators should ensure all persons are clear before operating truck or equipment. Before moving operators should sound horn or alarm, all equipment should be equipped with a working back up alarm;
- Haulage trucks or equipment with restricted visibility should be equipped with devices that eliminate blind spots;
- Employees should stay off haul roads. When approaching a haul area, employees should make eye contact and communicate their intentions directly with the equipment operator;
- If possible minimize steep grades on haul roads;

- Where grades are steep provide signage indicating the actual grade as well as measures for a runaway truck;
- Trucks are to be operated within the manufacturer's recommendations (for example- retarder charts indicate the combination of loads, grades and speeds that should not be exceeded if the truck's retarder is to work properly – to ensure the truck does not descend grade at speeds greater than listed);
- Haul roads should be well lit, sufficiently wide (at least 50% of the width of the equipment on both sides of road) and equipped with reflectors to indicate access points;
- Haul roads should have adequate right-of-way signs indicating haul directions;
- Haul trucks will follow designated haul roads; and
- Haul trucks will comply with posted speed limits.

9.9 Lockout/Tagout Activities

(Reference CH2M HILL SOP HSE-310, *Lockout and Tagout*)

Lockout/tagout (LO/TO) shall be performed whenever service or maintenance is necessary on equipment that could cause injury to personnel from the unexpected equipment energizing or start-up or unexpected release of stored energy. Energy sources requiring lockout/tagout may include electrical, pneumatic, kinetic, and potential.

If work on energized electrical systems is necessary—contact the RHSM. Specific training and procedures are required to be followed before any work on energized electrical systems can be performed and are NOT covered in this section. Energized electrical work is defined as work performed **on or near** energized electrical systems or equipment with exposed components operating at 50 volts or greater. Working near energized live parts is any activity inside a Limited Approach Boundary (anywhere from 3.5 feet to 24 feet [1 meter 7.3 meters] depending on voltage). Examples of energized electrical work include using a voltmeter to troubleshoot electrical systems and changing out controllers.

When lockout/tagout is necessary to perform maintenance/repair of a system, all the requirements of SOP HSE-310, Lockout and Tagout, shall be met including the following bulleted items:

- When CH2M HILL controls the work, CH2M HILL must verify that subcontractors affected by the unexpected operation of equipment develop a written lockout/tagout program, provide training on lockout/tagout procedures and coordinate its program with other affected subcontractors. This may include compliance with the owner or facility lockout/tagout program.
- When CH2M HILL personnel are affected by the unexpected operation of equipment they must complete the electrical safety awareness module on the VO. Authorized personnel shall inform the affected personnel of the LO/TO. Affected personnel shall not tamper with LO/TO devices.
- Standard lockout/tagout procedures include the following six steps: 1) notify all personnel in the affected area of the lockout/tagout, 2) shut down the equipment using normal operating controls, 3) isolate all energy sources, 4) apply individual lock and tag to each energy isolating device, 5) relieve or restrain all potentially hazardous stored or residual energy, and 6) verify that isolation and deenergization of the equipment has been accomplished. Once verified that the equipment is at the zero energy state, work may begin.
- All safe guards must be put back in place, all affected personnel notified that lockout has been removed and controls positioned in the safe mode prior to lockout removal. Only the individual who applied the lock and tag may remove them.

- CH2M HILL authorized employees shall complete the LO/TO training module on the VO and either the electrical safety training module on the VO or 10-hour construction training. The authorized employee must also be trained and qualified on the system they are working on (e.g., qualified electrician for working on electrical components of a system).
- When equipment-specific LO/TO procedures are not available or when existing procedures are determined to be insufficient, CH2M HILL authorized employees shall also complete the Equipment-Specific LO/TO Procedure Development Form, provided as an attachment to this HSP, to create an equipment-specific lockout/tagout procedure.

9.10 Portable Generator Hazards

(Reference CH2M HILL SOP HSE-206, Electrical Safety)

- Portable generators are useful when temporary or remote electric power is needed, but they also can be hazardous. The primary hazards to avoid when using a generator are carbon monoxide (CO) poisoning from the toxic engine exhaust, electric shock or electrocution, and fire.
- NEVER use a generator indoors or in similar enclosed or partially-enclosed spaces. Generators can produce high levels of carbon monoxide (CO) very quickly. When you use a portable generator, remember that you cannot smell or see CO. Even if you can't smell exhaust fumes, you may still be exposed to CO.
- If you start to feel sick, dizzy, or weak while using a generator, get to fresh air RIGHT AWAY. DO NOT DELAY. The CO from generators can rapidly lead to full incapacitation and death.
- If you experience serious symptoms, get medical attention immediately. Inform project staff that CO poisoning is suspected. If you experienced symptoms while indoors have someone call the fire department to determine when it is safe to re-enter the building.
- Follow the instructions that come with your generator. Locate the unit outdoors and away from doors, windows, and vents that could allow CO to come indoors.
- Ensure the generator is grounded in accordance with the manufacturer's operation manual.
- Keep the generator dry and do not use in rain or wet conditions. To protect from moisture, operate it on a dry surface under an open, canopy-like structure. Dry your hands if wet before touching the generator.
- Plug appliances directly into the generator. Or, use a heavy duty, outdoor-rated extension cord that is rated (in watts or amps) at least equal to the sum of the connected appliance loads. Check that the entire cord is free of cuts or tears and that the plug has all three prongs, especially a grounding pin.
- Most generators come with Ground Fault Circuit Interrupters (GFCI). Test the GFCIs daily to determine whether they are working
- If the generator is not equipped with GFCI protected circuits plug a portable GFCI into the generator and plug appliances, tools and lights into the portable GFCI.
- Never store fuel near the generator or near any sources of ignition.
- Before refueling the generator, turn it off and let it cool down. Gasoline spilled on hot engine parts could ignite.

9.11 Pressure Washing Operations

Below are the hazard controls and safe work practices to follow when working around or performing pressure washing.

- Only trained, authorized personnel may operate the high-pressure washer.
- Follow manufacturer's safety and operating instructions.
- Inspect pressure washer before use and confirm deadman trigger is fully operational
- The wand must always be pointed at the work area.
- The trigger should never be tied down
- Never point the wand at yourself or another worker.
- The wand must be at least 42 inches (1.1 meter) from the trigger to the tip and utilize greater than 10 degree tips.
- The operator must maintain good footing.
- Non-operators must remain a safe distance from the operator.
- No unauthorized attachment may be made to the unit.
- Do not modify the wand.
- All leaks or malfunctioning equipment must be repaired immediately or the unit taken out-of-service.
- Polycoated Tyvek or equivalent, 16-inch-high steel-toed rubber boots, safety glasses, hard hat with face shield, and inner and outer nitrile gloves will be worn, at a minimum.

9.12 Stream Crossing

Traversing streams present significant hazards, including drowning, hypothermia, and abrasions. When crossing streams, be sure to implement the bulleted items below.

- When walking in streams, first plan the route. Look ahead for exits should there be any difficulty during the crossing, and "read" the water for spots to avoid such as drop offs, sunken logs, and tricky currents.
- Do seek out the safest route – narrow, low flow, shallow. Evaluate deeper and faster moving sections with caution. Backtracking is often dangerous or impossible once committed.
- If streams to be crossed are deeper than "knee deep", find an alternate crossing location that is less deep.
- Streams should be crossed while facing upstream, stepping side to side, and using a sturdy walking stick. When possible, wade a stream diagonally, moving downstream. Move slowly, keeping the foot on the upstream side in the lead and pointed forward. Your rear, or anchor, foot should point downstream and be at right angles to the lead foot. Move the lead foot forward about half a step, feeling for a solid hold. Next, move the anchor foot forward the same distance – shuffle across so that your anchor foot never passes the lead. This way both feet are always in position to lend support. If you must turn around, do so toward the upstream direction.
- Don't attempt to cross above rocky rapids or a cascade. Step on submersed rocks with great care.
- If you are working in streams, algae covered rocks should be assumed slippery until tested. Always be alert for unstable and extremely slippery rocks.

- Rocks with green moss or attached plants offer better traction or even better, look for gravel and sand pockets among the stream boulders, which are much more stable, and use a wading staff (if not carrying one, find a suitable one nearby) to steady your balance while crossing. Use a solid wading staff instead of the collapsible type.
- Be cautious of areas where there are submerged or partially submerged trees/tree branches – these can create entanglement hazards during a crossing or a "swim".
- If streams are crossed that are deeper than "crotch deep", personnel must use either ropes and/or wear chest waders.
- Choose the right waders (with RHSM/SC involvement).
- Footwear with felt-bottom soles are ideal for rocky bottom streams. The rough texture cuts through algae growing on the rocks and grips well. For very slippery conditions, consider studded felt soles or a slipover, studded sandal. However, felt soles do not provide good traction on muddy, slippery banks. Cleated soles work well for mud or sand bottom streams (a hard molded tread pattern similar to a hiking boot).
- Wear a wading belt with chest waiters to keep your waders from billowing out like a parachute; the currents will carry you and move you in ways you don't want to move.
- Never wade alone.
- If the wader fills with water, don't panic. Waders full of water weigh less in water than on land and the water inside doesn't add any weight as long as you are in the water. Also a common fear is that air trapped in the waders will raise the feet higher than the head and force the face underwater is unfounded. Waders do streamline your legs and kicking is useless. Follow these steps if the waders fill with water:
    - Don't try to take them off in the water
    - In calm water, wade or swim to shore
    - In fast-moving water, ride the current:
    - Pull your feet up in front of you, bend your knees
    - Point your feet downstream (so the feet, not the head will bounce off the rocks)
    - Sculling with your hands will help direct to the nearest shallow area
    - When you reach calm water, go ashore and empty your waders
    - Don't waste energy in the vertical position going for the bottom. This position is virtually impossible to maintain and leads quickly to exhaustion (the major cause of drowning).
    - Concentrate on getting out of the water and not saving the equipment.
- The higher the elevation you are at, the steeper the stream gradient is. This means the stream can rise quicker and return to lower flow more quickly.
- Always wait out a swollen stream if at all possible.
- If you do slip into the water and are being swept downstream, don't panic. Cold water will be a shock for 2-3 seconds. Pull your knees up, face your feet downstream and lean back, using your hands as best you can to navigate and get to the bank. Keep your head up; you don't want your head underwater banging into rocks. If you stay calm, you can reach water where you can stand up or swim to the bank.
- When walking along stream banks and not entering streams, wear work boots.

9.13 Traffic Control

(Reference CH2M HILL SOP HSE-216, *Traffic Control*)

The following precautions must be taken when working around traffic, and in or near an area where traffic controls have been established by a sub contractor. Ensure the requirements in the referenced SOP are followed.

- Exercise caution when exiting traveled way or parking along street – avoid sudden stops, use flashers, etc.
- Park in a manner that will allow for safe exit from vehicle, and where practicable, park vehicle so that it can serve as a barrier.
- All staff working adjacent to traveled way or within work area must wear reflective/high-visibility safety vests.
- Eye protection should be worn to protect from flying debris.
- Remain aware of factors that influence traffic related hazards and required controls – sun glare, rain, wind, flash flooding, limited sight-distance, hills, curves, guardrails, width of shoulder (i.e., breakdown lane), etc.
- Always remain aware of an escape route (e.g., behind an established barrier, parked vehicle, guardrail, etc).
- Always pay attention to moving traffic – never assume drivers are looking out for you.
- Work as far from traveled way as possible to avoid creating confusion for drivers.
- When workers must face away from traffic, a "buddy system" should be used, where one worker is looking towards traffic.
- When working on highway projects, obtain a copy of the contractor's traffic control plan.
- Work area should be protected by a physical barrier – such as a K-rail or Jersey barrier.
- Review traffic control devices to ensure that they are adequate to protect your work area. Traffic control devices should: 1) convey a clear meaning, 2) command respect of road users, and 3) give adequate time for proper traffic response. The adequacy of these devices are dependent on limited sight distance, proximity to ramps or intersections, restrictive width, duration of job, and traffic volume, speed, and proximity.
- Either a barrier or shadow vehicle should be positioned a considerable distance ahead of the work area. The vehicle should be equipped with a flashing arrow sign and truck-mounted crash cushion (TMCC). All vehicles within 40 feet (12.2 meters) of traffic should have an orange flashing hazard light atop the vehicle.
- Except on highways, flaggers should be used when 1) two-way traffic is reduced to using one common lane, 2) driver visibility is impaired or limited, 3) project vehicles enter or exit traffic in an unexpected manner, or 4) the use of a flagger enhances established traffic warning systems.
- Lookouts should be used when physical barriers are not available or practical. The lookout continually watches approaching traffic for signs of erratic driver behavior and warns workers.
- Vehicles should be parked at least 40 feet (12.2 meters) away from the work zone and traffic. Minimize the amount of time that you will have your back to oncoming traffic.
- Traffic control training module on the VO shall be completed when CH2M HILL workers who work in and around roadways and who exposed to public vehicular traffic.

9.14 Utilities (underground)

An assessment for underground utilities must be conducted where there is a potential to contact underground utilities or similar subsurface obstructions during intrusive activities. Intrusive activities include excavation, trenching, drilling, hand augering, soil sampling, or similar activities.

The assessment must be conducted before any intrusive subsurface activity and must include at least the following elements:

1. A background and records assessment of known utilities or other subsurface obstructions.
2. Contacting and using the designated local utility locating service.
3. Conducting an independent field survey to identify, locate, and mark potential underground utilities or subsurface obstructions. *Note: This is independent of, and in addition to, any utility survey conducted by the designated local utility locating service above.*
4. A visual survey of the area to validate the chosen location.

When any of these steps identifies an underground utility within 5 feet (1.5 meters) of intrusive work, then non-aggressive means must be used to physically locate the utility before a drill rig, backhoe, excavator or other aggressive method is used.

Aggressive methods are never allowed within 2 feet of an identified high risk utility (see paragraph below).

Any deviation from these requirements must be approved by the Responsible HS Manager and the Project Manager.

Background and Records Assessment of Known Utilities

Identify any client- or location-specific permit and/or procedural requirements (e.g., dig permit or intrusive work permit) for subsurface activities. For military installations, contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Obtain available utility diagrams and/or as-built drawings for the facility.

Review locations of possible subsurface utilities including sanitary and storm sewers, electrical lines, water supply lines, natural gas lines, fuel tanks and lines, communication lines, lighting protection systems, etc. Note: Use caution in relying on as-built drawings as they are rarely 100 percent accurate.

Request that a facility contact with knowledge of utility locations review and approve proposed locations of intrusive work.

Designated Local Utility Locating Service

Contact your designated local utility locating service (e.g., Dig-Safe, Blue Stake, One Call) to identify and mark the location of utilities. Call 811 in the US or go to www.call811.com to identify the appropriate local service group. Contacting the local utility locating service is a legal requirement in most jurisdictions.

Independent Field Survey (Utility Locate)

The organization conducting the intrusive work (CH2M HILL or subcontractor) shall arrange for an independent field survey to identify, locate, and mark any potential subsurface utilities in the work area. This survey is in addition to any utility survey conducted by the designated local utility locating service.

The independent field survey provider shall determine the most appropriate instrumentation/technique or combinations of instrumentation/techniques to identify subsurface utilities based on their experience and expertise, types of utilities anticipated to be present, and specific site conditions.

A CH2M HILL or subcontractor representative must be present during the independent field survey to observe the utility locate and verify that the work area and utilities have been properly identified and marked. If there is any question that the survey was not performed adequately or the individual was not qualified, then arrangements must be made to obtain a qualified utility locate service to re-survey the area. Obtain documentation of the survey and clearances in writing and signed by the party conducting the clearance. Maintain all documentation in the project file.

If the site owner (military installation or client) can provide the independent field survey, CH2M HILL or the subcontractor shall ensure that the survey includes:

- Physically walking the area to verify the work location and identify, locate, and mark underground utility locations:
- Having qualified staff available and instrumentation to conduct the locate;
- Agreeing to document the survey and clearances in writing.
- Should any of the above criteria not be met, CH2M HILL or subcontractor must arrange for an alternate independent utility locate service to perform the survey.
- The markings from utility surveys must be protected and preserved until the markings are no longer required. If the utility location markings are destroyed or removed before intrusive work commences or is completed, the PM, SC, or designee must notify the independent utility locate service or the designated local utility locating service to resurvey and remark the area.

Visual Assessment before and during Intrusive Activities

Perform a "360 degree" assessment. Walk the area and inspect for utility-related items such as valve caps, previous linear cuts, patchwork in pavement, hydrants, manholes, utility vaults, drains, and vent risers in and around the dig area.

The visual survey shall include all surface landmarks, including manholes, previous liner cuts, patchwork in pavement, pad-mounted transformers, utility poles with risers, storm sewer drains, utility vaults, and fire hydrants.

If any unanticipated items are found, conduct further research before initiating intrusive activities and implement any actions needed to avoid striking the utility or obstruction.

Subsurface Activities within 5 feet of an Underground Utility or if there is Uncertainty

When aggressive intrusive activities will be conducted within 5 feet (1.5 meters) of an underground utility or when there is uncertainty about utility locations, locations must be physically verified by non-aggressive means such as air or water knifing, hand digging, or human powered hand augering. Non-conductive tools must be used if electrical hazards may be present. If intrusive activities are within 5 feet (1.5 meters) and parallel to a marked existing utility, the utility location must be exposed and verified by non-aggressive methods every 100 feet (30.5 meters). Check to see if the utility can be isolated during intrusive work.

Intrusive Activities within 2 feet of an Underground Utility

Use non-aggressive methods (hand digging, vacuum excavation, etc.) to perform intrusive activities within 2 feet of a high risk utility (i.e., a utility that cannot be de-energized or would cause significant impacts to repair/ replace). Hazardous utilities shall be de-energized whenever possible.

Spotter

A spotter shall be used to monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon, presence of pea gravel or sand in soils, presence of concrete or other debris in soils, refusal of auger or excavating equipment). If any suspicious conditions are encountered stop work immediately and contact the PM or RHSM to evaluate the situation. The spotter must have a method to alert an operator to stop the intrusive activity (e.g., air horn, hand signals).

9.15 Utilities (overhead)

Proximity to Power Lines

No work is to be conducted within 50 feet (15.2 meters) of overhead power lines without first contacting the utility company to determine the voltage of the system. No aspect of any piece of equipment is to be operated within 50 feet (15.2 meters) of overhead power lines without first making this determination.

Operations adjacent to overhead power lines are PROHIBITED unless one of the following conditions is satisfied:

- Power has been shut off, positive means (such as lockout) have been taken to prevent the lines from being energized, lines have been tested to confirm the outage, and the utility company has provided a signed certification of the outage.
- The minimum clearance from energized overhead lines is as shown in the table below, or the equipment will be repositioned and blocked to ensure that no part, including cables, can come within the minimum clearances shown in the table.

MINIMUM DISTANCES FROM POWERLINES

Powerlines Nominal System Kv	Minimum Required Distance, Feet (Meters)
0-50	10 (3.0)
50-200	15 (4.6)
201-350	20 (6.1)
351-500	25 (7.6)
501-750	35 (10.7)
751-1000	45 (13.7)
Over 1000	Established by utility owner/operator or by a professional engineer in electrical power transmission/distribution

(These distances have been determined to eliminate the potential for arcing based on the line voltage.)

- The power line(s) has been isolated through the use of insulating blankets which have been properly placed by the utility. If insulating blankets are used, the utility will determine the minimum safe operating distance; get this determination in writing with the utility representative's signature.
- All inquiries regarding electric utilities must be made in writing and a written confirmation of the outage/isolation must be received by the PM prior to the start of work.

9.16 Vinyl Chloride

(Reference CH2M HILL, SOP HSE-512, *Vinyl Chloride*)

Vinyl Chloride is considered a "Confirmed Human Carcinogen." Vinyl Chloride has a mild, sweet, chloroform-like odor.

CH2M HILL is required to control employee workplace exposure to vinyl chloride when personal exposures are at or above 1.0 ppm as an 8-hour time-weighted average (TWA) or above 5.0 ppm short term exposure limit (STEL), by implementing a program that meets the requirements of the Occupational Safety and Health Administration (OSHA) Vinyl Chloride standard, 29 CFR 1910.1017. The elements of the CH2M HILL vinyl chloride program include the following:

- Exposure monitoring
- Methods of control, including personal protective equipment (PPE) and respirators
- Medical surveillance
- Training on hazards of vinyl chloride and control measures (includes project-specific training and the computer-based training on CH2M HILL's Virtual Office, *Vinyl Chloride)*
- Record keeping requirements

If air monitoring indicates there is potential exposure at the action level concentrations above, notify the RHSM to ensure the above have been adequately addressed. Other exposure control measures include:

- Do not enter regulated work areas unless training, medical monitoring, and PPE requirements established by the competent person have been met.
- Do not eat, drink, smoke, chew tobacco or gum, or apply cosmetics in regulated areas.
- Respiratory protection and other exposure controls selection shall be based on the most recent exposure monitoring results obtained from the competent person.
- Review the fact sheet included as an attachment to this HSP.
- Wear a high visibility safety vest or high visibility clothing

9.17 Working Alone

(Reference CH2M HILL Core Standard, *Working Alone*)

Personnel can only be tasked to work alone by the Project Manager who shall assess potential hazards and appropriate control measures, with assistance from the Responsible Health and Safety Manager (RHSM).

"Lone workers" with an accountability system in place is permitted, depending on the hazards presented during the execution of the task. Reference the "Lone Worker Protocol" included as an attachment to this HSP.

The employee shall at all times be equipped with a working voice communication device such as a cellular phone or two-way radio to check-in to their project contact (s) at pre-determined times.

Call in contact name:	•
Phone numbers (office and cell):	•

Check-in or contact times must be based on the risk associated with the task, or the timeframe expected to complete the task, but at a minimum of at least two times during an 8 hour work shift.

Call in contact Form shall be completed by lone worker and given to call in contact prior to going into the field. Refer to the "Lone Worker Protocol" attached to this HSP.

Work tasks will cease if communication is lost during work day. Work may resume when communication is re-established.

9.18 Working Over Water

If any activities pose a risk to drowning implement the following during the activity:

- Fall protection should be provided to prevent personnel from falling into water. Where fall protection systems are not provided and the danger of drowning exists, U.S. Coast Guard-approved personal flotation devices (PFDs), or a life jacket, shall be worn.
- Provide employees with an approved (USCG for U.S. operations) life jacket or buoyant work vest.
  - Employees should inspect life jackets or work vests daily before use for defects. Do not use defective jackets or vests.
- Post ring buoys with at least 90 feet (27.4 meters) of 3/8-inch solid-braid polypropylene (or equal) line next to the work area. If the work area is large, post extra buoys 200 feet (61 meters) or less from each other.
- Provide at least one life saving skiff, immediately available at locations where employees are working over or adjacent to water.
  - Ensure the skiff is in the water and capable of being launched by one person and is equipped with both motor and oars.
- Designate at least one employee on site to respond to water emergencies and operate the skiff at times when there are employees above water.
  - If the designated skiff operator is not within visual range of the water, provide him or her with a radio or provide some form of communication to inform them of an emergency.
  - Designated employee should be able to reach a victim in the water within three to four minutes.
- Ensure at least one employee trained in CPR and first aid is on site during work activities.

10.0 Physical Hazards and Controls

Physical hazards include exposure to temperature extremes, sun, noise, and radiation. If you encounter a physical hazard that has not been identified in this plan, contact the RHSM so that a revision to this plan can be made.

10.1 Noise

(Reference CH2M HILL SOP HSE-108, *Hearing Conservation*)

CH2M HILL is required to control employee exposure to occupational noise levels of 85 decibels, A-weighted, (dBA) and above by implementing a hearing conservation program that meets the requirements of the OSHA Occupational Noise Exposure standard, 29 CFR 1910.95. A noise assessment may be conducted by the RHSM or designee based on potential to emit noise above 85 dBA and also considering the frequency and duration of the task.

- Areas or equipment emitting noise at or above 90dBA shall be evaluated to determine feasible engineering controls. When engineering controls are not feasible, administrative controls can be developed and appropriate hearing protection will be provided.
- Areas or equipment emitting noise levels at or above 85 dBA, hearing protection must be worn.
- Employees exposed to 85 dBA or a noise dose of 50% must participate in the Hearing Conservation program including initial and annual (as required) audiograms.
- The RHSM will evaluate appropriate controls measures and work practices for employees who have experienced a standard threshold shift (STS) in their hearing.
- Employees who are exposed at or above the action level of 85 dBA are required to complete the online Noise Training Module located on CH2M HILL's virtual office.
- Hearing protection will be maintained in a clean and reliable condition, inspected prior to use and after any occurrence to identify any deterioration or damage, and damaged or deteriorated hearing protection repaired or discarded.
- In work areas where actual or potential high noise levels are present at any time, hearing protection must be worn by employees working or walking through the area.
- Areas where tasks requiring hearing protection are taking place may become hearing protection required areas as long as that specific task is taking place.
- High noise areas requiring hearing protection should be posted or employees must be informed of the requirements in an equivalent manner and a copy of the OSHA standard 29 CFR 1910.95 shall be posted in the workplace.

10.2 Ultraviolet Radiation (sun exposure)

Health effects regarding ultraviolet (UV) radiation are confined to the skin and eyes. Overexposure can result in many skin conditions, including erythema (redness or sunburn), photoallergy (skin rash), phototoxicity (extreme sunburn acquired during short exposures to UV radiation while on certain medications), premature skin aging, and numerous types of skin cancer. Implement the following controls to avoid sunburn.

Limit Exposure Time

- Rotate staff so the same personnel are not exposed all of the time.
- Limit exposure time when UV radiation is at peak levels (approximately 2 hours before and after the sun is at its highest point in the sky).
- Avoid exposure to the sun, or take extra precautions when the UV index rating is high.

Provide Shade

- Take lunch and breaks in shaded areas.
- Create shade or shelter through the use of umbrellas, tents, and canopies.
- Fabrics such as canvas, sailcloth, awning material and synthetic shade cloth create good UV radiation protection.
- Check the UV protection of the materials before buying them. Seek protection levels of 95 percent or greater, and check the protection levels for different colors.

Clothing

- Reduce UV radiation damage by wearing proper clothing; for example, long sleeved shirts with collars, and long pants. The fabric should be closely woven and should not let light through.
- Head protection should be worn to protect the face, ears, and neck. Wide-brimmed hats with a neck flap or "Foreign Legion" style caps offer added protection.
- Wear UV-protective sunglasses or safety glasses. These should fit closely to the face. Wrap-around style glasses provide the best protection.

Sunscreen

- Apply sunscreen generously to all exposed skin surfaces at least 20 minutes before exposure, allowing time for it to adhere to the skin.
- Re-apply sunscreen at least every 2 hours, and more frequently when sweating or performing activities where sunscreen may be wiped off.
- Choose a sunscreen with a high sun protection factor (SPF). Most dermatologists advocate SPF 30 or higher for significant sun exposure.
- Waterproof sunscreens should be selected for use in or near water, and by those who perspire sufficiently to wash off non-waterproof products.
- Check for expiration dates, because most sunscreens are only good for about 3 years. Store in a cool place out of the sun.
- No sunscreen provides 100 percent protection against UV radiation. Other precautions must be taken to avoid overexposure.

10.3 Temperature Extremes

(Reference CH2M HILL SOP HSE-211, *Heat and Cold Stress*)

Each employee is responsible for the following:

- Recognizing the symptoms of heat or cold stress;
- Taking appropriate precautionary measures to minimize their risk of exposure to temperature extremes (see following sections); and
- Communicating any concerns regarding heat and cold stress to their supervisor or SC.

10.3.1 Heat

Heat-related illnesses are caused by more than just temperature and humidity factors.

Physical fitness influences a person's ability to perform work under heat loads. At a given level of work, the more fit a person is, the less the physiological strain, the lower the heart rate, the lower the body temperature (indicates less retrained body heat—a rise in internal temperature precipitates heat injury), and the more efficient the sweating mechanism.

Acclimatization is the degree to which a worker's body has physiologically adjusted or acclimatized to working under hot conditions. Acclimatization affects their ability to do work. Acclimatized individuals sweat sooner and more profusely than un-acclimatized individuals. Acclimatization occurs gradually over 1 to 2 weeks of continuous exposure, but it can be lost in as little as 3 days in a cooler environment.

Dehydration reduces body water volume. This reduces the body's sweating capacity and directly affects its ability to dissipate excess heat.

The ability of a body to dissipate heat depends on the ratio of its surface area to its mass (surface area/weight). **Heat dissipation** is a function of surface area, while heat production depends on body mass. Therefore, overweight individuals (those with a low ratio) are more susceptible to heat-related illnesses because they produce more heat per unit of surface area than if they were thinner. Monitor these persons carefully if heat stress is likely.

When wearing **impermeable clothing**, the weight of an individual is not as important in determining the ability to dissipate excess heat because the primary heat dissipation mechanism, evaporation of sweat, is ineffective.

SYMPTOMS AND TREATMENT OF HEAT STRESS					
	Heat Syncope	Heat Rash	Heat Cramps	Heat Exhaustion	Heat Stroke
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature.
Treatment	Remove to cooler area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	Use mild drying lotions and powders, and keep skin clean for drying skin and preventing infection.	Remove to cooler area. Rest lying down. Increase fluid intake.	Remove to cooler area. Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	Cool rapidly by soaking in cool– but not cold– water. Call ambulance, and get medical attention immediately!

Precautions

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50°Fahrenheit (10 degrees Celsius [C]) to 60°Fahrenheit (F) (15.6 degrees C) should be available. Under severe conditions, drink 1 to 2 cups every 20 minutes, for a total of 1 to 2 gallons (7.5 liters) per day. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.
- Acclimate yourself by slowly increasing workloads (do not begin with extremely demanding activities).
- Use cooling devices, such as cooling vests, to aid natural body ventilation. These devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.
- Avoid direct sun whenever possible, which can decrease physical efficiency and increase the probability of heat stress. Take regular breaks in a cool, shaded area. Use a wide-brim hat or an umbrella when working under direct sun for extended periods.
- Provide adequate shade to protect personnel against radiant heat (sun, flames, hot metal).
- Maintain good hygiene standards by frequently changing clothing and showering.
- Observe one another for signs of heat stress. PREVENTION and communication is key.

Thermal Stress Monitoring

- The following procedures should be implemented when personnel are **wearing protective clothing** that limits the cooling process (e.g., use of Tyvek, multiple layers of clothing, thermally insulating clothing) and the **heat index** (takes into account temperature and humidity) exceeds 70° F (21 degrees C), or when the workers exhibit symptoms of heat stress:
- The heart rate should be measured by the radial pulse for 30 seconds, as early as possible in the resting period.
- The heart rate at the beginning of the rest period should not exceed 110 beats per minute, or 20 beats per minute above resting pulse.

- If the heart rate is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same.
- If the pulse rate still exceeds 110 beats per minute at the beginning of the next rest period, the following work cycle should be further shortened by 33 percent.
- Continue this procedure until the rate is maintained below 110 beats per minute, or 20 beats per minute above resting pulse.
- Alternately, the oral temperature can be measured before the workers have something to drink.
- If the oral temperature exceeds 99.6 degrees F (37.6 degrees C) at the beginning of the rest period, the following work cycle should be shortened by 33 percent.
- Continue this procedure until the oral temperature is maintained below 99.6 degrees F (37.6 degrees C). While an accurate indication of heat stress, oral temperature is difficult to measure in the field.
- Use the form attached to this HSP to track workers' measurements and actions taken.

Procedures for when Heat Illness Symptoms are Experienced

- **Always** contact the RHSM when any heat illness related symptom is experienced so that controls can be evaluated and modified, if needed.
- In the case of cramps, reduce activity, increase fluid intake, move to shade until recovered.
- In the case of all other heat-related symptoms (fainting, heat rash, heat exhaustion), and if the worker is a CH2M HILL worker, contact the occupational physician at 1-866-893-2514 and immediate supervisor.
- In the case of heat stroke symptoms, call 911, have a designee give location and directions to ambulance service if needed, follow precautions under the emergency medical treatment of this HSP.
- Follow the Incident Notification, Reporting, and Investigation section of this HSP.

10.3.2 Cold

General

Low ambient temperatures increase the heat lost from the body to the environment by radiation and convection. In cases where the worker is standing on frozen ground, the heat loss is also due to conduction.

Wet skin and clothing, whether because of water or perspiration, may conduct heat away from the body through evaporative heat loss and conduction. Thus, the body cools suddenly when chemical protective clothing is removed if the clothing underneath is perspiration soaked.

Movement of air across the skin reduces the insulating layer of still air just at the skin's surface. Reducing this insulating layer of air increases heat loss by convection.

Non-insulating materials in contact or near-contact with the skin, such as boots constructed with a metal toe or shank, conduct heat rapidly away from the body.

Certain common drugs, such as alcohol, caffeine, or nicotine, may exacerbate the effects of cold, especially on the extremities. These chemicals reduce the blood flow to peripheral parts of the body, which are already high-risk areas because of their large surface area to volume ratios. These substances may also aggravate an already hypothermic condition.

Precautions

- Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in wet weather.
- Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- Wind-Chill Index (below) is used to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For those reasons, it should only be used as a guideline to warn workers when they are in a situation that can cause cold-related illnesses.
- Persons who experience initial signs of immersion foot, frostbite, and/or hypothermia should report it immediately to their supervisor/PM to avoid progression of cold-related illness.
- Observe one another for initial signs of cold-related disorders.
- Obtain and review weather forecast – be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.

SYMPTOMS AND TREATMENT OF COLD STRESS			
	Immersion (Trench) Foot	**Frostbite**	**Hypothermia**
Signs and Symptoms	Feet discolored and painful; infection and swelling present.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Re-warm area quickly in warm–but **not** hot–water. Have victim drink warm fluids, but **not** coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but **not** coffee or alcohol. Get medical attention.

Wind Chill Chart

Wind (mph) \ Temperature (°F)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

10.4 Radiological Hazards

Refer to CH2M HILL's Core Standard, Radiological Control and Radiological Controls Manual for additional requirements.

Hazards	Controls
None Known	None Required

11.0 Biological Hazards and Controls

Biological hazards are everywhere and change with the region and season. If you encounter a biological hazard that has not been identified in this plan, contact the RHSM so that a revision to this plan can be made. Whether it is contact with a poisonous plant, a poisonous snake, or a bug bite, do not take bites or stings lightly. If there is a chance of an allergic reaction or infection, or to seek medical advice on how to properly care for the injury, contact the occupational nurse at 1-866-893-2514.

11.1 Bees and Other Stinging Insects

Bees and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic. Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform your supervisor and/or a buddy. If you are stung, contact the occupational nurse at 1-866-893-2514. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for an allergic reaction if you have never been stung before. Call 911 if the reaction is severe.

11.2 Bird Droppings

Large amounts of bird droppings may present a disease risk. The best way to prevent exposure to fungus spores in bird droppings is to avoid disturbing it. A brief inhalation exposure to highly contaminated dust may be all that is needed to cause infection and subsequent development of fungal disease.

If disturbing the droppings or if removal is necessary to perform work, follow these controls:

- Use dust control measures (wetting with water or HEPA vacuuming) for all activities that may generate dust from the accumulated droppings.
- Wear Tyvek with hoods, disposable gloves and booties, and air-purifying respirators with a minimum N95 rating.
- Put droppings into plastic/poly bags and preferably into a 55-gallon drum to prevent bag from ripping.

11.3 Feral Dogs

Avoid all dogs – both leashed and stray. Do not disturb a dog while it is sleeping, eating, or caring for puppies. If a dog approaches to sniff you, stay still. An aggressive dog has a tight mouth, flattened ears and a direct stare. If you are threatened by a dog, remain calm, do not scream and avoid eye contact. If you say anything, speak calmly and firmly. Do not turn and run, try to stay still until the dog leaves, or back away slowly until the dog is out of sight or you have reached safety (e.g. vehicle). If attacked, retreat to vehicle or attempt to place something between you and the dog. If you fall or are knocked to the ground, curl into a ball with your hands over your head and neck and protect your face. If bitten, contact the occupational nurse at 1-866-893-2514. Report the incident to the local authorities.

11.4 Hantavirus

Hantavirus pulmonary syndrome (HPS) is a disease caused by a virus which can be transmitted from certain rodents to humans and is prevalent throughout the southwestern United States. Avoid disturbing rodent nests.

Nesting material and droppings must be removed if work is necessary in a rodent-infested area. PPE for removal shall include:

- Tyvek coveralls;
- Rubber boots or disposable shoe covers;
- Rubber, latex, or vinyl gloves;
- Respiratory protection such as a full face or half-mask air-purifying respirator with a high-efficiency particulate air (HEPA) filter; and
- Protective goggles if wearing a half-mask respirator.

Spray any urine, droppings, and nesting materials with either a bleach and water solution (1 parts bleach to 9 parts water) or a household disinfectant prepared according to the label instructions for dilution and disinfection time. Soak well and let stand for 15 minutes. Use a paper towel or rag to pick up the materials and dispose of them.

Mop floors after spraying them using bleach and water solution or a disinfectant. Dirt floors can be sprayed with either bleach and water solution or a disinfectant.

Personal protective gear shall be decontaminated upon removal at the end of the day. All potentially infective waste material (including respirator filters) from clean-up operations shall be double-bagged in plastic bags.

Symptoms of HPS

Symptoms develop between 14 and 31 days after exposure to infected rodents and include fatigue, fever, and muscle aches, especially the large muscle groups--thighs, hips, back and sometimes shoulders. About half of all HPS patients also experience headaches, dizziness, chills and/or abdominal pain. Four to 10 days after the initial phase of the illness, late symptoms of HPS may appear. These include coughing and shortness of breath. If you develop symptoms suggestive of HPS, call the occupational nurse at 1-866-893-2514.

11.5 Mosquito Bites

Due to the recent detection of the West Nile Virus in the southwestern United States it is recommended that preventative measures be taken to reduce the probability of being bitten by mosquitoes whenever possible. Mosquitoes are believed to be the primary source for exposure to the West Nile Virus as well as several other types of encephalitis. The following guidelines should be followed to reduce the risk of these concerns for working in areas where mosquitoes are prevalent:

- Stay indoors at dawn, dusk, and in the early evening;
- Wear long-sleeved shirts and long pants whenever you are outdoors;
- Spray clothing with repellents containing permethrin or N,N-diethyl-meta-toluamide (DEET) since mosquitoes may bite through thin clothing;
- Apply insect repellent sparingly to exposed skin. An effective repellent will contain 35% DEET. Repellents may irritate the eyes and mouth, so avoid applying repellent to the hands; and

- Whenever you use an insecticide or insect repellent, be sure to read and follow the manufacturer's DIRECTIONS FOR USE, as printed on the product.

Vitamin B and "ultrasonic" devices are NOT effective in preventing mosquito bites.

Symptoms of Exposure to the West Nile Virus

Most infections are mild, and symptoms include fever, headache, and body aches, occasionally with skin rash and swollen lymph glands. More severe infection may be marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, paralysis, and, rarely, death.

The West Nile Virus incubation period is from 3 to 15 days.

Contact the project RHSM with questions, and immediately report any suspicious symptoms to your supervisor, PM, and contact the occupational nurse at 1-866-893-2514.

11.6 Poison Ivy, Poison Oak, and Poison Sumac

Poison ivy, poison oak, and poison sumac typically are found in brush or wooded areas. They are more commonly found in moist areas or along the edges of wooded areas. Shrubs are usually 12 to 30 inches high, or can also be a tree-climbing vine, with triple leaflets and short, smooth hair underneath. Plants are red and dark green in spring and summer, with yellowing leaves anytime especially in dry areas. Leaves may achieve bright reds in fall, but plants lose its (yellowed, then brown) leaves in winter, leaving toxic stems. All parts of the plant remain toxic throughout the seasons. These plants contain urushiol a colorless or pale yellow oil that oozes from any cut or crushed part of the plant, including the roots, stems and leaves and causes allergic skin reactions when contacted. The oil is active year round.

Become familiar with the identity of these plants (see below). Wear protective clothing that covers exposed skin and clothes. Avoid contact with plants and the outside of protective clothing. If skin contacts a plant, wash the area with soap and water immediately. If the reaction is severe or worsens, seek medical attention.

Poison Ivy

Poison Sumac

Poison Oak

Contamination with poison ivy, sumac or oak can happen through several pathways, including:

- Direct skin contact with any part of the plant (even roots once above ground foliage has been removed).
- Contact with clothing that has been contaminated with the oil.
- Contact from removing shoes that have been contaminated (shoes are coated with urishol oil).
- Sitting in a vehicle that has become contaminated.
- Contact with any objects or tools that have become contaminated.

- Inhalation of particles generated by weed whacking, chipping, vegetation clearing.

If you must work on a site with poison ivy, sumac or oak the following precautions are necessary:

- Do not drive vehicles onto the site where it will come into contact with poison ivy, sumac or oak. Vehicles which need to work in the area, such as drill rigs or heavy equipment must be washed as soon as possible after leaving the site.
- All tools used in the poison ivy, sumac or oak area, including those used to cut back poison oak, surveying instruments used in the area, air monitoring equipment or other test apparatus must be decontaminated before they are placed back into the site vehicle. If on-site decontamination is not possible, use plastic to wrap any tools or equipment until they can be decontaminated.
- Personal protective equipment, including Tyvek coveralls, gloves, and boot covers must be worn. PPE must be placed into plastic bags and sealed if they are not disposed immediately into a trash receptacle.
- As soon as possible following the work, shower to remove any potential contamination. Any body part with suspected or actual exposure should be washed with Zanfel, Tecnu or other product designed for removing urushiol. If you do not have Zanfel or Tecnu wash with cold water. Do not take a bath, as the oils can form and invisible film on top of the water and contaminate your entire body upon exiting the bath.
- Tecnu may also be used to decontaminate equipment.
- Use IvyBlock or similar products to prevent poison oak, ivy and sumac contamination. Check with the closest CH2M HILL warehouse to see if these products are available. Follow all directions for application.

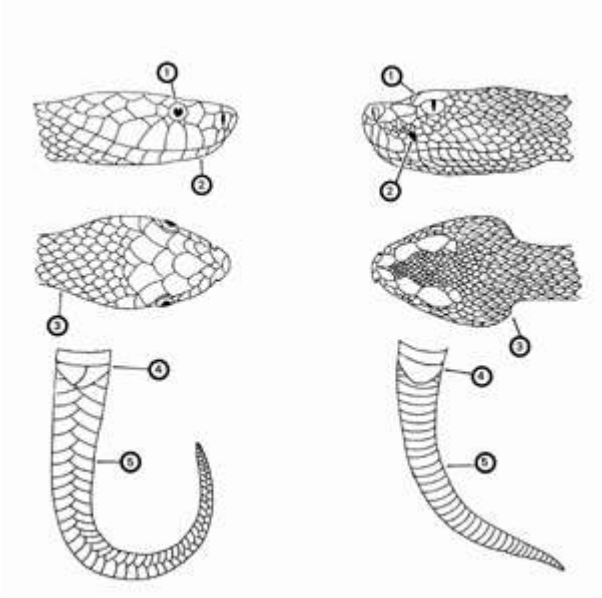
If you do come into contact with one of these poisonous plants and a reaction develops, contact your supervisor and the occupational nurse 1-866-893-2514.

11.7 Snakes

Snakes typically are found in underbrush and tall grassy areas. If you encounter a snake, stay calm and look around; there may be other snakes. Turn around and walk away on the same path you used to approach the area. If bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Call the occupational nurse at 1-866-893-2514 immediately. Do not apply ice, cut the wound, or apply a tourniquet. Try to identify the type of snake: note color, size, patterns, and markings. Below is a guide to identifying poisonous snakes from non-poisonous snakes.

Identification of Poisonous Snakes

Major Identification Features Non-venomous Snake	Major Identification Features Venomous Snake
1. Round pupils	1. Elliptical pupils
2. No sensing pit	2. Sensing pit between eye and nostril
3. Head slightly wider than neck	3. Head much wider than neck
4. Divided anal plate	4. Single anal plate
5. Double row of scales on the underside of the tail	5. Single scales on the underside of the tail



11.8 Spiders - Brown Recluse and Widow

The Brown Recluse spider can be found most anywhere in the United States. It varies in size in shape, but the distinguishing mark is the violin shape on its body. They are typically non-aggressive. Keep an eye out for irregular, pattern-less webs that sometimes appear almost tubular built in a protected area such as in a crevice or between two rocks. The spider will retreat to this area of the web when threatened.

The Black Widow, Red Widow and the Brown Widow are all poisonous. Most have globose, shiny abdomens that are predominantly black with red markings (although some may be pale or have lateral stripes), with moderately long, slender legs. These spiders are nocturnal and build a three-dimensional tangled web, often with a conical tent of dense silk in a corner where the spider hides during the day.

Hazard Controls

- Inspect or shake out any clothing, shoes, towels, or equipment before use.
- Wear protective clothing such as a long-sleeved shirt and long pants, hat, gloves, and boots when handling stacked or undisturbed piles of materials.
- Minimize the empty spaces between stacked materials.
- Remove and reduce debris and rubble from around the outdoor work areas.
- Trim or eliminate tall grasses from around outdoor work areas.

- Store apparel and outdoor equipment in tightly closed plastic bags.
- Keep your tetanus boosters up-to-date (every 10 years). Spider bites can become infected with tetanus spores.

If you think you have been bit by a poisonous spider, immediately call the occupational nurse at 1-866-893-2514 and follow the guidance below:

- Remain calm. Too much excitement or movement will increase the flow of venom into the blood;
- Apply a cool, wet cloth to the bite or cover the bite with a cloth and apply an ice bag to the bite;
- Elevate the bitten area, if possible;
- Do not apply a tourniquet, do not try to remove venom; and
- Try to positively identify the spider to confirm its type. If the spider has been killed, collect it in a plastic bag or jar for identification purposes. Do not try to capture a live spider—especially if you think it is a poisonous spider.

Black Widow

Red Widow

Brown Widow

Brown Recluse

11.9 Ticks

Every year employees are exposed to tick bites at work and at home putting them at risk of illness. Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch (6.4 mm) in size.

In some geographic areas exposure is not easily avoided. Wear tightly woven light-colored clothing with long sleeves and pant legs tucked into boots; spray only outside of clothing with permethrin or permanone and spray skin with only DEET; and check yourself frequently for ticks.

Where site conditions (vegetation above knee height, tick endemic area) or when tasks (having to sit or kneel in vegetation) diminish the effectiveness of the other controls mentioned above, bug-out suits (check with your local or regional warehouse) or Tyvek shall be used. Bug-out suits are more breathable than Tyvek.

Take precautions to avoid exposure by including pre-planning measures for biological hazards prior to starting field work. Avoid habitats where possible, reduce the abundance through habitat disruption or application of acracide. If these controls aren't feasible, contact your local or regional warehouse for preventative equipment such as repellants, protective clothing and tick removal kits. Use the buddy system and perform tick inspections prior to entering the field vehicle. If ticks were not planned to be encountered and are observed, do not continue field work until these controls can be implemented.

See Tick Fact Sheet attached to this HSP for further precautions and controls to implement when ticks are present. If bitten by a tick, follow the removal procedures found in the tick fact sheet, and call the occupational nurse at 1-866-893-2514.

Be aware of the symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme disease is a rash that might appear that looks like a bullseye with a small welt in the center. RMSF is a rash of red spots under the skin 3 to 10 days after the tick bite. In both RMSF and Lyme disease, chills, fever, headache, fatigue, stiff neck, and bone pain may develop. If symptoms appear, again contact the occupational nurse at 1-866-893-2514.

Be sure to complete an Incident Report (either use the Hours and Incident Tracking System [HITS] system on the VO) if you do come in contact with a tick.

12.0 Contaminants of Concern

The table below summarizes the potential contaminants of concern (COC) and their occupational exposure limit and signs and symptoms of exposure. The table also includes the maximum concentration of each COC and the associated location and media that was sampled (groundwater, soil boring, surface soil). These concentrations were used to determine engineering and administrative controls described in the "Project-Specific Hazard Controls" section of this HSP, as well as PPE and site monitoring requirements.

Contaminants of Concern

Contaminant	Location and Maximum[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
2-Butanone (Methyl Ethyl Ketone, MEK)	GW: SB: SS:	200 ppm	3,000	Eye, skin, and nose irritation; headache; dizziness; vomiting; dermatitis	9.54
Trichloroethylene (TCE)	GW: SB: SS:	10 ppm	1,000 Ca	Headache, vertigo, visual disturbance, eye and skin irritation, fatigue, giddiness, tremors, sleepiness, nausea, vomiting, dermatitis, cardiac arrhythmia, paresthesia, liver injury	9.45
Vinyl Chloride	GW: SB: SS:	1 ppm	NL Ca	Weakness, abdominal pain, gastrointestinal bleeding, enlarged liver, pallor or cyanosis of extremities	9.99

Footnotes:

[a] Specify sample-designation and media: SB (Soil Boring), A (Air), D (Drums), GW (Groundwater), L (Lagoon), TK (Tank), SS (Surface Soil), SL (Sludge), SW (Surface Water).
[b] Appropriate value of permissible exposure limit (PEL), recommended exposure limit (REL), or threshold limit valute (TLV) listed.
[c] IDLH = immediately dangerous to life and health (units are the same as specified "Exposure Limit" units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.
[d] PIP = photoionization potential; NA = Not applicable; UK = Unknown.

eV = electron volt
mg/kg = milligram per kilogram
mg/m^3 = milligrams per cubic meter
ug/m^3 = micrograms per cubic meter

Potential Routes of Exposure

Dermal: Contact with contaminated media. This route of exposure is minimized through use of engineering controls, administrative controls and proper use of PPE.	**Inhalation:** Vapors and contaminated particulates. This route of exposure is minimized through use of engineering controls, administrative controls and proper use of respiratory protection when other forms of control do not reduce the potential for exposure.	**Other:** Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

13.0 Site Monitoring

(Reference CH2M HILL SOP HSE-207, *Exposure Monitoring for Airborne Chemical Hazards*)

When performing site monitoring, record all the information, such as in a field logbook. Note date and time, describe monitoring location (for example, in breathing zone, at source and site location), and what the reading is. If any action levels are reached, note it in the field logbook and note the action taken.

Exposure records (air sampling) must be preserved for the duration of employment plus thirty years. Ensure that copies of the field log book are maintained in the project file.

Copies of all project exposure records (e.g., copies of field logbook pages where air monitoring readings are recorded and associated calibration) shall be sent to the regional SPA for retention and maintained in the project files.

13.1 Direct Reading Monitoring Specifications

Instrument	Tasks	Action Levels[a]	Action to be Taken when Action Level reached	Frequency [b]	Calibration
Toxic Gas Monitor: MultiRAE Plus with 10.6 eV lamp (VOCs, O_2, LEL, CO,, H_2S) FID and/or PID may be substituted for MultiRae, contact HSM for guidance if needed.	All Intrusive Task and Sampling Activities	0 – 1 ppm 1-5 ppm 5> ppm	Level D Level C Level B, Not Authorized. Contact RHSM	Initially and periodically during task Collect vinyl chloride Drager tube when MultiRae >1 ppm and is sustained for 5 minutes	Daily
	All Intrusive Task and Sampling Activities	0-10% : 10-25% LEL: >25% LEL:	No explosion hazard Potential explosion hazard Explosion hazard; evacuate or vent	Continuous	Daily
	All Intrusive Task and Sampling Activities	>25%[c] O_2: 20.9%[c] O_2: <19.5%[c] O_2:	Explosion hazard; evacuate or vent Normal O_2 O_2 deficient; vent or use SCBA	Continuous	Daily
Colormetric Tube: Vinyl chloride specific (0.5 to 30 ppm range) with pre-tube, or equivalent	All Intrusive Task and Sampling Activities	<0.5 ppm 0.5-10 ppm >10 ppm	Level D Level C (verify cartridge availability/compatibility) Level B	Initially and periodically when PID/FID >1 ppm	Not applicable
Noise-Level Monitor [d]	All Equipment operations	<85 dB(A) 85-120 dB(A) 120 dB(A)	No action required Hearing protection required Stop; re-evaluate	Initially and periodically during task	Daily

[a] Action levels apply to sustained breathing-zone measurements above background.
[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SC; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate.
[c] If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply only to ambient working atmospheres, and not to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry.
[d] Noise monitoring and audiometric testing also required.

13.2 Calibration Specifications

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Instrument	Gas	Span	Reading	Method
PID: 10.6 or 11.7 eV bulb **5 Gas Meter (MultiRAE)**	100 ppm isobutylene	RF = 1.0	100 ppm	1.5 lpm reg T-tubing
MultiRae or equivalent	H2S CO LEL O2 100 ppm isobutylene	CF = 25 CF = 50 CF = 50 CF = 20.9 CF = 100	25 ppm 50 ppm 50 % 20.9 % 100 ppm	1.5 lpm reg T-tubing

Calibrate air monitoring equipment daily (or prior to use) in accordance with the instrument's instructions. Document the calibration in the field logbook (or equivalent) and include the following information:

- Instrument name
- Serial Number
- Owner of instrument (for example, CH2M HILL, HAZCO)
- Calibration gas (including type and lot number)
- Type of regulator (for example, 1.5 lpm)
- Type of tubing (for example, direct or T-tubing)
- Ambient weather condition (for example, temperature and wind direction)
- Calibration/instrument readings
- Operator's name and signature
- Date and time

13.3 Integrated Personal Air Sampling

Sampling, in addition to real-time monitoring, may be required by other OSHA regulations where there may be exposure to certain contaminants. Air sampling typically is required when site contaminants include lead, cadmium, arsenic, asbestos, and certain volatile organic compounds. Contact the RHSM immediately if these contaminants are encountered.

Method Description

None

Personal Breathing Zone and Area Samples

Personal breathing zone and area sampling results must be sent immediately to the RHSM.

Employees potentially exposed to the substances for which air sampling is being performed shall be given the opportunity to observe the exposure measurements, and records shall be made available to all affected employees upon request or when they are required to be provided by a specific regulation. Employees may also receive a copy of their exposure records from the Medical Surveillance Program Administrator (MSPA).

14.0 Personal Protective Equipment

(Reference CH2M HILL- SOP HSE-117, *Personal Protective Equipment*)

14.1 Required Personal Protective Equipment

PPE must be worn by employees when actual or potential hazards exist and engineering controls or administrative practices cannot adequately control those hazards.

A PPE assessment has been conducted by the RHSM based on project tasks (see PPE specifications below). Verification and certification of assigned PPE by task is completed by the RHSM that approved this plan. Below are items that need to be followed when using any form of PPE:

- Employees must be trained to properly wear and maintain the PPE;
- Employees must be trained in the limitations of the PPE;
- In work areas where actual or potential hazards are present at any time, PPE must be worn by employees working or walking through the area;
- Areas requiring PPE should be posted or employees must be informed of the requirements in an equivalent manner;
- PPE must be inspected prior to use and after any occurrence to identify any deterioration or damage;
- PPE must be maintained in a clean and reliable condition;
- Damaged PPE shall not be used and must either be repaired or discarded; and
- PPE shall not be modified, tampered with, or repaired beyond routine maintenance.

The table below outlines PPE to be used according to task based on project-specific hazard assessment. If a task other than the tasks described in this table needs to be performed, contact the RHSM so this table can be updated.

Project-Specific Personal Protective Equipment Requirements[a]

Task	Level	Body	Head	Respirator [b]
-General site entry -Surveying/Utility Locate -Observation of material loading for offsite disposal -Oversight of remediation and construction	D	Work clothes; safety toed leather work boots and gloves	Hardhat [c] Safety glasses with side shields Ear protection [d]	None required

Project-Specific Personal Protective Equipment Requirements[a]

Task	Level	Body	Head	Respirator [b]
-Monitoring Well Installation/Development -Pore Sample Point Installation -Groundwater Sampling -Pore Water Sample Collection -Packing/Shipping Samples -Investigation-derived waste (drum) sampling and disposal **if contact with contaminated sediment, soil or water is anticipated	Modified D	Work clothes or cotton coveralls **Boots:** Safety-toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves. OR Work Clothes or Coveralls. SC to determine body protection based on potential contact with site contaminants. If outer layer of personal clothing cannot be kept clean, then outer cotton coveralls or uncoated Tyvek coveralls shall be worn. (Polycoated Tyvek when there is potential to contact contaminated groundwater or free liquids from drums.)	Hardhat [c] Safety glasses with side shields Ear protection [d]	None required
Work near vehicular traffic ways or earth moving equipment.	All	Appropriate level of ANSI/ISEA 107-2010 high-visibility safety vests.	Work near vehicular traffic ways or earth moving equipment.	
Equipment decontamination if using pressure washer	Modified D with splash protection	**Coveralls:** Polycoated Tyvek® **Boots:** 16-inch-high steel-toed rubber boots **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] over safety glasses with side shields or splash goggles Ear protection [d]	None required.
Tasks requiring upgrade[d] **As determined by RHSM/SSC**	C	**Coveralls:** Polycoated Tyvek® **Boots:** Safety -toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME P100 cartridges or equivalent.
Tasks requiring upgrade[d] **As determined by RHSM**	B	**Coveralls:** Polycoated Tyvek® **Boots:** Safety -toe, chemical-resistant boots OR Safety -toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	Positive-pressure demand self-contained breathing apparatus (SCBA); MSA Ultralite, or equivalent.

Reasons for Upgrading or Downgrading Level of Protection (with approval of the RHSM)	
Upgrade[f]	**Downgrade**
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels in the "Site Monitoring" section exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decrease the hazard. • Change in work task that will reduce contact with hazardous materials.

[a] Modifications are as indicated. CH2M HILL will provide PPE only to CH2M HILL employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to be determined by the SC.
[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet (1 meter) or less without shouting.
[e] See cartridge change-out schedule.
[f] Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the RHSM, and an SC qualified at that level is present.

14.2 Respiratory Protection

(Reference CH2M HILL SOP HSE-121, *Respiratory Protection*)

Implement the following when using respiratory protection:

- Respirator users must have completed appropriate respirator training within the past 12 months. Level C training is required for air-purifying respirators (APR) use and Level B training is required for supplied-air respirators (SAR) and self-contained breathing apparatus (SCBA) use. Specific training is required for the use of powered air-purifying respirators (PAPR);
- Respirator users must complete the respirator medical monitoring protocol and been approved for the specific type of respirator to be used;
- Tight-fitting facepiece respirator (negative or positive pressure) users must have passed an appropriate fit test within past 12 months;
- Respirator use shall be limited to those activities identified in this plan. If site conditions change that alters the effectiveness of the specified respiratory protection, the RHSM shall be notified to amend the written plan;
- Tight-fitting facepiece respirator users shall be clean-shaven and shall perform a user seal check before each use;
- Canisters/cartridges shall be replaced according to the change-out schedule specified in this plan. Respirator users shall notify the SC or RHSM of any detection of vapor or gas breakthrough. The SC shall report any breakthrough events to the RHSM for schedule upgrade;
- Respirators in regular use shall be inspected before each use and during cleaning;
- Respirators in regular use shall be cleaned and disinfected as often as necessary to ensure they are maintained in a clean and sanitary condition;
- Respirators shall be properly stored to protect against contamination and deformation;
- Field repair of respirators shall be limited to routine maintenance. Defective respirators shall be removed from service;
- When breathing air is supplied by cylinder or compressor, the SC or RHSM shall verify the air meets Grade D air specifications; and

- The SC or designee shall complete the Self-Assessment Checklist – Respiratory Protection included in as attachment to this plan to verify compliance with CH2M HILL's respiratory protection program.

Respirator Change-Out Schedule

Contaminant	Change-Out Schedule
Vinyl Chloride	End-of-service life or end of shift (whichever occurs first)

15.0 Worker Training and Qualification

15.1 CH2M HILL Worker Training

(Reference CH2M HILL SOP HSE-110, *Training*)

15.1.1 Hazardous Waste Operations Training

All employees engaging in hazardous waste operations or emergency response shall receive appropriate training as required by 29 CFR 1910.120 and 29 CFR 1926.65. At a minimum, the training shall have consisted of instruction in the topics outlined in 29 CFR 1910.120 and 29 CFR 1926.65. Personnel who have not met these training requirements shall not be allowed to engage in hazardous waste operations or emergency response activities.

Initial Training

General site workers engaged in hazardous waste operations shall, at the time of job assignment, have received a minimum of 40 hours of initial health and safety training for hazardous waste site operations, unless otherwise noted in the above-referenced standards.

Employees who may be exposed to health hazards or hazardous substances at treatment, storage, and disposal (TSD) operations shall receive a minimum of 24 hours of initial training to enable the employee to perform their assigned duties and functions in a safe and healthful manner.

Employees engaged in emergency response operations shall be trained to the level of required competence in accordance with 29 CFR 1910.120.

Three-Day Actual Field Experience

General site workers for hazardous waste operations shall have received three days of actual experience (on-the-job training) under the direct supervision of a trained, qualified supervisor and shall be documented. If the field experience has not already been received and documented at a similar site, this supervised experience shall be accomplished and documented at the beginning of the assignment of the project.

Refresher Training

General site workers and TSD workers shall receive 8-hours of refresher training annually (within the previous 12-month period) to maintain qualifications for fieldwork. Employees engaged in emergency response operations shall receive annual refresher training of sufficient content and duration to maintain their competencies or shall demonstrate competency in those areas at least annually.

Eight-Hour Supervisory Training

On site management or supervisors who will be directly responsible for, or supervise employees engaged in hazardous waste site operations, will have received at least 8 hours of additional specialized training on managing such operations. Employees designated as Safety Coordinator – Hazardous Waste are considered 8-hour HAZWOPER Site Safety Supervisor trained.

15.1.2 First Aid/Cardiopulmonary Resuscitation

First aid and CPR training consistent with the requirements of a nationally recognized organization such as the American Red Cross Association or National Safety Council shall be administered by a certified trainer. A minimum of two personnel per active field operation will have first aid and CPR training. Bloodborne pathogen training located on CH2M HILL's Virtual Office is also required for those designated as first aid/CPR trained.

15.1.3 Safety Coordinator Training

SCs are trained to implement the HSE program on CH2M HILL field projects. A qualified SC is required to be identified in the site-specific HSP for CH2M HILL field projects. SCs must also meet the requirements of the worker category appropriate to the type of field project (construction or hazardous waste). In addition, the SCs shall have completed additional safety training required by the specific work activity on the project that qualifies them to implement the HSE program (for example, fall protection, excavation).

15.1.4 Site-Specific Training

Prior to commencement of field activities, all field personnel assigned to the project will have completed site-specific training that will address the contents of applicable HSPs, including the activities, procedures, monitoring, and equipment used in the site operations. Site-specific training will also include site and facility layout, potential hazards, risks associated with identified emergency response actions, and available emergency services. This training allows field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safety and work operations for their particular activity.

15.1.5 Project-Specific Training Requirements

Project-specific training for this project includes:

- Training on CH2M HILL HSP and AHAs;
- Training on subcontractor or client AHAs;
- Drilling (Subcontractor)
- Forklift Operator Training (CH2M HILL or Subcontractor)

The training listed below is required computer-based training located on CH2M HILL's Virtual Office (VO) at

https://www.int.ch2m.com/safety%5Fcounts/Training/Computer_Based_Courses.asp

- Lifting training (part of new employee orientation training or available on the Virtual Office);
- Lockout/Tagout training (on the Virtual Office)
- Vinyl Chloride Exposure training (on the Virtual Office)
- Bloodborne Pathogen Training (on the Virtual Office)
- Dangerous Goods training (on the Virtual Office)
- Environmental Awareness (on the Virtual Office)

- Noise Exposure training (on the Virtual Office)
- Hand Safety (on the Virtual Office)

Project Manager/Site Supervisor Training

Project managers or persons having site supervision responsibilities must complete

- Project Manager/Site Supervisor Training(on the Virtual Office)

Initial Safety Coordinator Training.(on the Virtual Office)

16.0 Medical Surveillance and Qualification

(Reference CH2M HILL SOP HSE-113, *Medical Surveillance*

All site workers participating in hazardous waste operations or emergency response (HAZWOPER) will maintain an adequate medical surveillance program in accordance with 29 CFR 1910.120 or 29 CFR 1926.65 and other applicable OSHA standards. Documentation of employee medical qualification (e.g., physician's written opinion) will be maintained in the project files and made available for inspection.

16.1 Hazardous Waste Operations and Emergency Response

CH2M HILL personnel expected to participate in on site HAZWOPER tasks are required to have a current medical qualification for performing this work. Medical qualification shall consist of a qualified physician's written opinion regarding fitness for duty at a hazardous waste site, including any recommended limitations on the employee's assigned work. The physician's written opinion shall state whether the employee has any detected medical conditions that would place the employee at increased risk of material impairment of the employee's health from work in hazardous waste operations or emergency response, or from respirator use.

16.2 Job or Site-Specific Medical Surveillance

Due to the nature of hazards for a particular job or work site, specialized medical surveillance may be necessary. This surveillance could include biological monitoring for specific compounds, or specialized medical examinations.

Site-specific medical surveillance includes:

- N/A

16.3 Respirator User Qualification

Personnel required to wear respirators must have a current medical qualification to wear respirators. Medical qualification shall consist of a qualified physician's written opinion regarding the employee's ability to safely wear a respirator in accordance with 29 CFR 1910.134.

16.4 Hearing Conservation

Personnel working in hazardous waste operations or operations that fall under 29 CFR 1910.95 and exposed to noise levels in excess of the 85dBA time-weighted average shall be included in a hearing conservation program that includes annual audiometric testing.

17.0 Site-Control Plan

17.1 Site-Control Procedures

(Reference CH2M HILL SOP HSE-218, *Hazardous Waste Operations)*

Site control is established to prevent the spread of contamination throughout the site and to ensure that only authorized individuals are permitted into potentially hazardous areas.

The SC will implement site control procedures including the following bulleted items.

- Establish support, contamination reduction, and exclusion zones. Delineate with flags or cones as appropriate. Support zone should be upwind of the site. Use access control at entry and exit from each work zone.
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals;
  - Air horn; and
  - Two-way radio or cellular telephone if available.
- Establish offsite communication.
- Establish and maintain the "buddy system."

17.2 Remediation Work Area Zones

(Reference CH2M HILL SOP HSE-218 Hazardous Waste Operations)

A three-zone approach will be used to control areas where site contaminants exist. Access will be allowed only after verification of appropriate training and medical qualification. The three-zone approach shall include an EZ, Contamination Reduction Zone (CRZ) and a Support Zone (SZ). The three-zone approach is not required for construction work performed outside contaminated areas where control of site contamination is not a concern.

Specific work control zones shall be established as necessary during task planning. Site work zones should be modified in the field as necessary, based on such factors as equipment used, air monitoring results, environmental conditions, or alteration of work plans. The following guidelines shall be used for establishing and revising these preliminary zone designations.

17.2.1 Support Zone

The SZ is an uncontaminated area (trailers, offices, field vehicles, etc.) that will serve as the field support area for most operations. The SZ provides field team communications and staging for emergency response. Appropriate sanitary facilities and safety and emergency response equipment will be located in this zone. Potentially contaminated personnel/materials are not allowed in this zone. The only exception will be appropriately packaged and decontaminated materials, or personnel with medical emergencies that cannot be decontaminated.

17.2.2 Contamination Reduction Zone

The CRZ is established between the EZ and the SZ, upwind of the contaminated area where possible. The CRZ provides an area for decontamination of personnel, portable handheld equipment and tools, and heavy equipment. In addition, the CRZ serves as access for heavy equipment and emergency support services.

17.2.3 Exclusion Zone

The EZ is where activities take place that may involve exposure to site contaminants and/or hazardous materials or conditions. This zone shall be demarcated to prevent unauthorized entry. More than one EZ may be established if there are different levels of protection to be employed or different hazards that exist in the same work area. The EZ shall be large enough to allow adequate space for the activity to be completed, including field personnel and equipment, as well as necessary emergency equipment.

The EZ shall be demarcated with some form of physical barrier or signage. The physical barrier or signage shall be placed so that they are visible to personnel approaching or working in the area. Barriers and boundary markers shall be removed when no longer needed.

17.2.4 Other Controlled Areas

Other work areas may need to be controlled due to the presence of an uncontrolled hazard, to warn workers of requirements, or to prevent unauthorized entry. Examples include general construction work areas, open excavations, high noise areas, vehicle access areas, and similar activities or limited access locations. These areas shall be clearly demarcated with physical barriers (fencing, cones, reinforced caution tape or rope) as necessary and posted with appropriate signage.

18.0 Decontamination

(Reference CH2M HILL SOP HSE-218, *Hazardous Waste Operations*)

Decontamination areas will be established for work in potentially contaminated areas to prevent the spread of contamination. Decontamination areas should be located upwind of the exclusion zone where possible and should consider any adjacent or nearby projects and personnel. The SC must establish and monitor the decontamination procedures and their effectiveness. Decontamination procedures found to be ineffective will be modified by the SC. The SC must ensure that procedures are established for disposing of materials generated on the site.

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SC should establish areas for eating, drinking, and smoking.

18.1 Contamination Prevention

Preventing or avoiding contamination of personnel, tools, and equipment will be considered in planning work activities at all field locations. Good contamination prevention and avoidance practices will assist in preventing worker exposure and result in a more efficient decontamination process. Procedures for contamination prevention and avoidance include the following:

- Do not walk through areas of obvious or known contamination;
- Do not directly handle or touch contaminated materials;
- Make sure there are no cuts or tears in PPE;
- Fasten all closures in suits and cover them with duct tape, if appropriate;
- Take particular care to protect any skin injuries;
- Stay upwind of airborne contamination, where possible;
- Do not eat or drink in contaminated work areas;
- Do not carry food, beverages, tobacco, or flame-producing equipment into contaminated work areas;
- Minimize the number of personnel and amount of equipment in contaminated areas to that necessary for accomplishing the work;
- Choose tools and equipment with nonporous exterior surfaces that can be easily cleaned and decontaminated;
- Cover monitoring and sampling equipment with clear plastic, leaving openings for the sampling ports, as necessary; and
- Minimize the amount of tools and equipment necessary in contaminated areas.

18.2 Personnel and Equipment Decontamination

Personnel exiting an EZ must ensure that they are not spreading potential contamination into clean areas or increasing their potential for ingesting or inhaling potential contaminants. Personal decontamination may range from removing outer gloves as exiting the EZ, to proceeding through an outer layer doffing station including a boot and glove wash and rinse, washing equipment, etc. Equipment that has come into contact with contaminated media must also be cleaned/decontaminated when it is brought out of the EZ.

18.3 Decontamination During Medical Emergencies

Standard personnel decontamination practices will be followed whenever possible. For emergency life saving first aid and/or medical treatment, normal decontamination procedures may need to be abbreviated or omitted. In this situation, site personnel shall accompany contaminated victims to advise emergency response personnel on potential contamination present and proper decontamination procedures.

Outer garments may be removed if they do not cause delays, interfere with treatment, or aggravate the problem. Protective clothing can be cut away. If the outer garments cannot be safely removed, a plastic barrier between the individual and clean surfaces should be used to help prevent contaminating the inside of ambulances or medical personnel. Outer garments can then be removed at the medical facility.

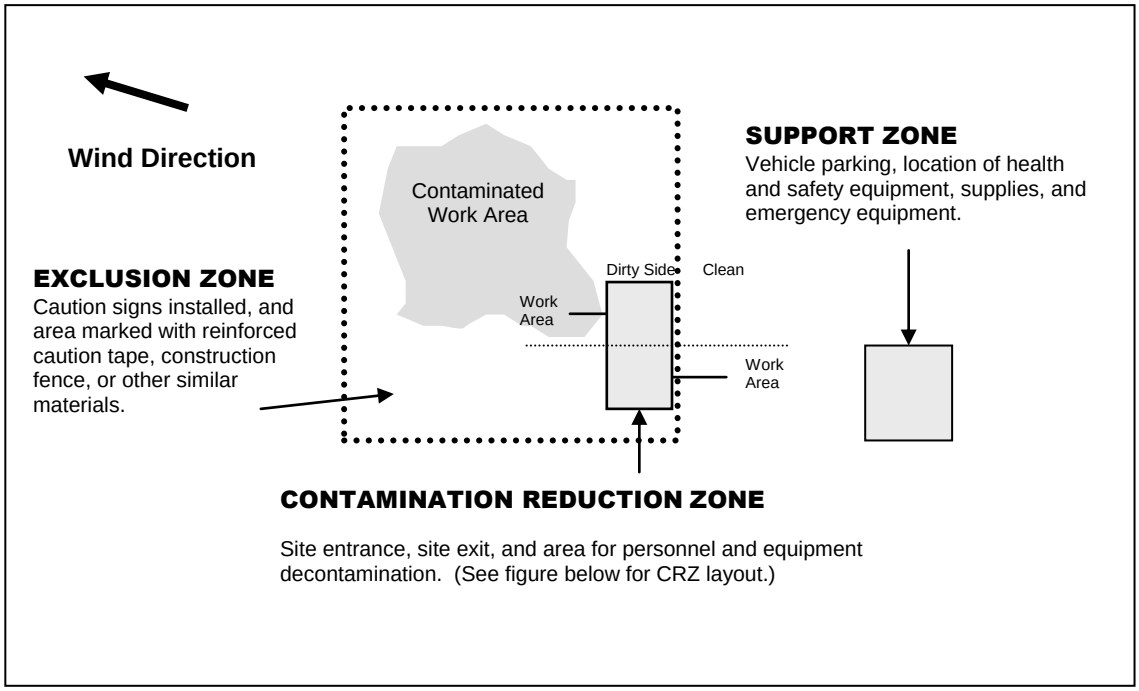
18.4 Waste Collection and Disposal

All contaminated material generated through the personnel and equipment decontamination processes (e.g., contaminated disposable items, gross debris, liquids, sludges) will be properly containerized and labeled, stored at a secure location, and disposed in accordance with the project plans.

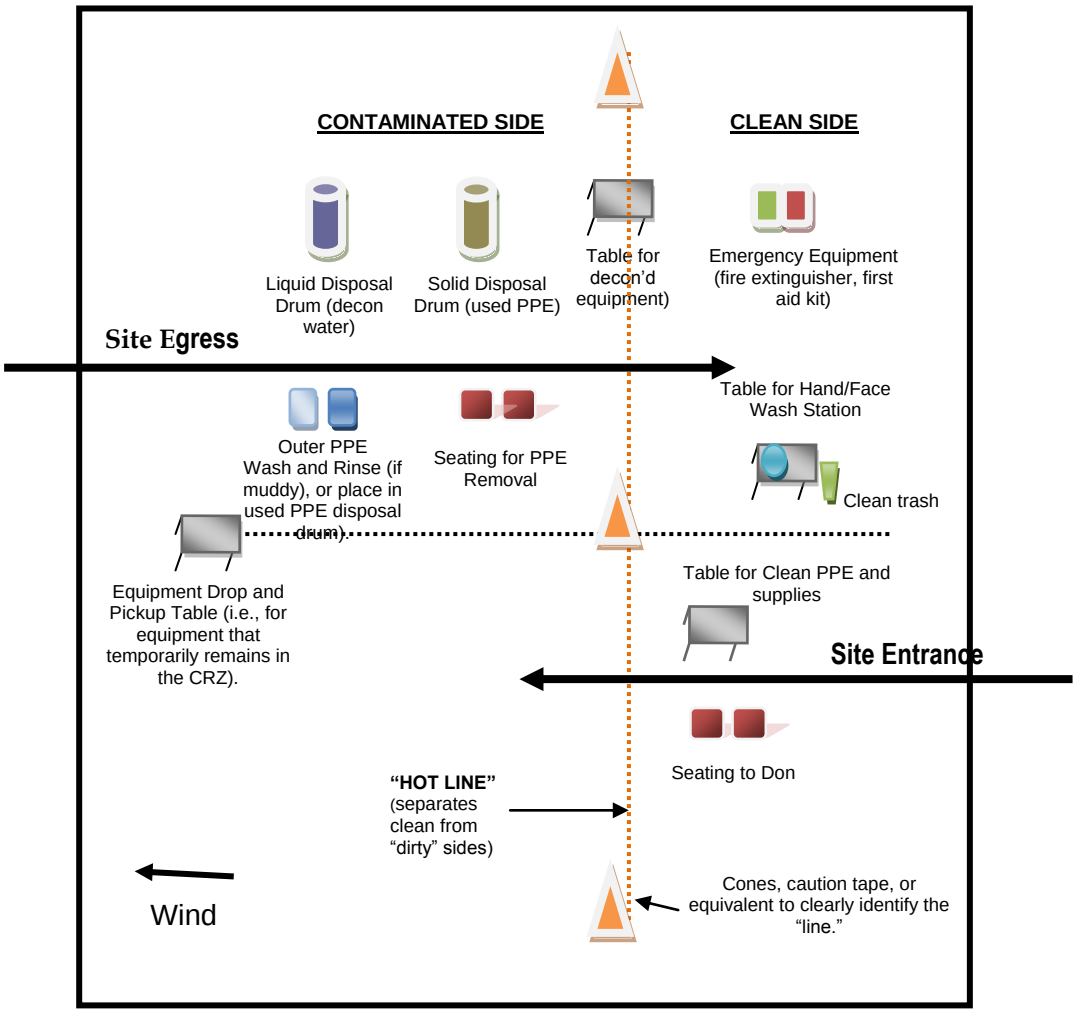
18.5 Diagram of Personnel-Decontamination Line

The following figure illustrates a conceptual establishment of work zones, including the decontamination line. Work zones are to be modified by the SC to accommodate task-specific requirements.

Work Area - Set up appropriately based on wind direction



Typical Contamination Reduction Zone



19.0 Emergency Response Plan

(Reference CH2M HILL SOP HSE-106, *Emergency Planning*)

19.1 Pre-Emergency Planning

The Emergency Response Coordinator (ERC), typically the SC or designee, performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with CH2M HILL onsite parties, the facility, and local emergency-service providers as appropriate. Pre-Emergency Planning activities performed by the ERC include:

- Review the facility emergency and contingency plans where applicable;
- Determine what onsite communication equipment is available (two-way radio, air horn);
- Determine what offsite communication equipment is needed (nearest telephone, cell phone);
- Confirm and post the "Emergency Contacts" page and route to the hospital located in this section in project trailer(s) and keep a copy in field vehicles along with evacuation routes and assembly areas. Communicate the information to onsite personnel and keep it updated;
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear;
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures;
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies;
- Inventory and check site emergency equipment, supplies, and potable water;
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, and releases;
- Rehearse the emergency response plan before site activities begin. This may include a "tabletop" exercise or an actual drill depending on the nature and complexity of the project. Drills should take place periodically but no less than once a year;
- Brief new workers on the emergency response plan; and
- The ERC will evaluate emergency response actions and initiate appropriate follow-up actions.

19.2 Emergency Equipment and Supplies

The ERC shall ensure the following emergency equipment is on the site. Verify and update the locations of this equipment as needed. The equipment will be inspected in accordance with manufacturer's recommendations. The inspection shall be documented in a field logbook or similar means to be kept in the project files.

Emergency Equipment and Supplies	Location
20 (or two 10) class A,B,C fire extinguisher	Support zone, field vehicle
First aid kit	Support zone, field vehicle
Eye Wash	Support zone, field vehicle
Potable water	Support zone, field vehicle
Bloodborne-pathogen kit	Support zone, field vehicle
Additional equipment (specify): Cell Phone, Spill kit	Support zone, field vehicle

19.3 Incident Response

In fires, explosions, or chemical releases, actions to be taken include the following:

- Notify appropriate response personnel;
- Shut down CH2M HILL operations and evacuate the immediate work area;
- Account for personnel at the designated assembly area(s);
- Assess the need for site evacuation, and evacuate the site as warranted;
- Implement HSE-111, Incident Notification, Reporting and Investigation; and
- Notify and submit reports to clients as required in contract.

Small fires or spills posing minimal safety or health hazards may be controlled with onsite spill kits or fire extinguishers without evacuating the site. When in doubt evacuate. Follow the incident reporting procedures in the "Incident Notification, Reporting, and Investigation" section of this HSP.

19.4 Emergency Medical Treatment

Emergency medical treatment is needed when there is a life-threatening injury (such as severe bleeding, loss of consciousness, breathing or heart has stopped). When in doubt if an injury is life-threatening or not, treat it as needing emergency medical treatment.

- Notify 911 or other appropriate emergency response authorities as listed in the "Emergency Contacts" page located in this section.
- The ERC will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury, perform decontamination (if applicable) where feasible; lifesaving and first aid or medical treatment takes priority.
- Initiate first aid and CPR where feasible.
- Notify supervisor and if the injured person is a CH2M HILL employee, the supervisor will call the occupational nurse at 1-866-893-2514 and make other notifications as required by HSE SOP-111, *Incident Notification, Reporting and Investigation*.
- Make certain that the injured person is accompanied to the emergency room.
- Follow the Serious Incident Reporting process in HSE SOP-111, Incident Notification, Reporting and Investigation, and complete incident report using the HITS system on the VO or if not feasible, use the hard copy forms provided as an attachment to this HSP.
- Notify and submit reports to client as required in contract.

19.5 Evacuation

- Evacuation routes, assembly areas, and severe weather shelters (and alternative routes and assembly areas) are to be specified on the site map.
- Evacuation route(s) and assembly area(s) will be designated by the ERC or designee before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The ERC and a "buddy" will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.

- The ERC will account for all personnel in the onsite assembly area.
- A designated person will account for personnel at alternate assembly area(s).
- The ERC will follow the incident reporting procedures in the "Incident Notification, Reporting and Investigation" section of this HSP.

19.6 Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy's wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

19.7 Inclement Weather

Sudden inclement weather can rapidly encroach upon field personnel. Preparedness and caution are the best defenses. Field crew members performing work outdoors should carry clothing appropriate for inclement weather. Personnel are to take heed of the weather forecast for the day and pay attention for signs of changing weather that indicate an impending storm. Signs include towering thunderheads, darkening skies, or a sudden increase in wind. If stormy weather ensues, field personnel should discontinue work and seek shelter until the storm has passed.

Protective measures during a lightning storm include seeking shelter; avoiding projecting above the surrounding landscape (don't stand on a hilltop--seek low areas); staying away from open water, metal equipment, railroad tracks, wire fences, and metal pipes; and positioning people several yards apart. Some other general precautions include:

- Know where to go and how long it will take to get there. If possible, take refuge in a large building or vehicle. Do not go into a shed in an open area;
- The inclination to see trees as enormous umbrellas is the most frequent and most deadly mistake. Do not go under a large tree that is standing alone. Likewise, avoid poles, antennae, and towers;
- If the area is wide open, go to a valley or ravine, but be aware of flash flooding;
- If you are caught in a level open area during an electrical storm and you feel your hair stand on end, drop to your knees, bend forward and put your hands on your knees or crouch. The idea is to make yourself less vulnerable by being as low to the ground as possible and taking up as little ground space as possible. Lying down is dangerous, since the wet earth can conduct electricity. Do not touch the ground with your hands; and
- Do not use telephones during electrical storms, except in the case of emergency.

Remember that lightning may strike several miles from the parent cloud, so work should be stopped and restarted accordingly. The lightning safety recommendation is 30-30: Seek refuge when thunder sounds within 30 seconds after a lightning flash; and do not resume activity until 30 minutes after the last thunder clap.

High winds can cause unsafe conditions, and activities should be halted until wind dies down. High winds can also knock over trees, so walking through forested areas during high-wind situations should be avoided. If winds increase, seek shelter or evacuate the area. Proper body protection should be worn in case the winds hit suddenly, because body temperature can decrease rapidly.

Emergency Contacts

24-hour CH2M HILL Injury Reporting– 1-866-893-2514
24-hour CH2M HILL Serious Incident Reporting Contact – 720-286-4911

Medical Emergency – 911
Facility Medical Response #:(910) 451-4841
(910) 451-4842
Onslow County ER (Off-Base) #: (910) 577-2240
Ambulance (On-Base) #: (910) 451-3004
(910) 451-3005
Ambulance (Public) #: (910) 451-9111
LEPC (Poison Control)#: (800) 222-1222

CH2M HILL- Medical Consultant
WorkCare
Dr. Peter Greaney M.D.
300 S. Harbor Blvd, Suite 600
Anaheim , CA 92805
800-455-6155/866-893-2514
714-978-7488

Fire/Spill Emergency – 911
Facility Fire Response #: (910) 451-9111

CH2M HILL Director – Health, Safety, Security & Environment
Andy Strickland/DEN
(720) 480-0685 (cell) or (720) 286-2393 (office)

Security & Police – 911
Facility Security #: (910) 451-2555

CH2M HILL Responsible Health and Safety Manager (RHSM)
Name: Carl Woods
Phone: (513) 319-5771

Utilities Emergency Phone Numbers
Water:
Gas: Contact Base EMD
Electric:

CH2M HILL Human Resources Department
Phone: Employee Connect toll-free number
1-877-586-4411
(U.S. and Canada)

CH2M HILL Project Manager
Name: Theron Grim
Phone: 908-268-5952

CH2M HILL Worker's Compensation:
Contact Business Group HR dept. to have form completed or contact Jennifer Rindahl after hours: (720)891-5382

CH2M HILL Safety Coordinator (SC)
Name: Kristin Rogers
Phone: 765-409-4278

Media Inquiries Corporate Strategic Communications
Name: John Corsi
Phone: (720) 286-2087

CH2M HILL Project Environmental Manager
Name: Hope Oaks
Phone: 678-530-4226

Automobile Accidents
Rental: Jennifer Rindahl/DEN: 720-286-2449
CH2M HILL owned vehicle: Linda George/DEN: 720-286-2057

Federal Express Dangerous Goods Shipping
Phone: 800/238-5355

CHEMTEL (hazardous material spills)
Phone: 800/255-3924

Facility Alarms: TBD

Evacuation Assembly Area(s): TBD by SC-HW

Facility/Site Evacuation Route(s): follow main roads towards success gates and off the base

Directions to Local Hospital

Local Hospital Nearest On-Base hospital:

Base Naval Hospital (only to be used in extreme emergency)
Building NH100
100 Brewster Blvd.
Camp Lejeune, NC 28547
Phone: (910) 451-4840, (910) 451-4841, (910) 451-4842

Local hospital:

Onslow County Memorial Hospital
317 Western Boulevard
Jacksonville, NC 28546
Phone: (910) 577-2240

Local ambulance service:

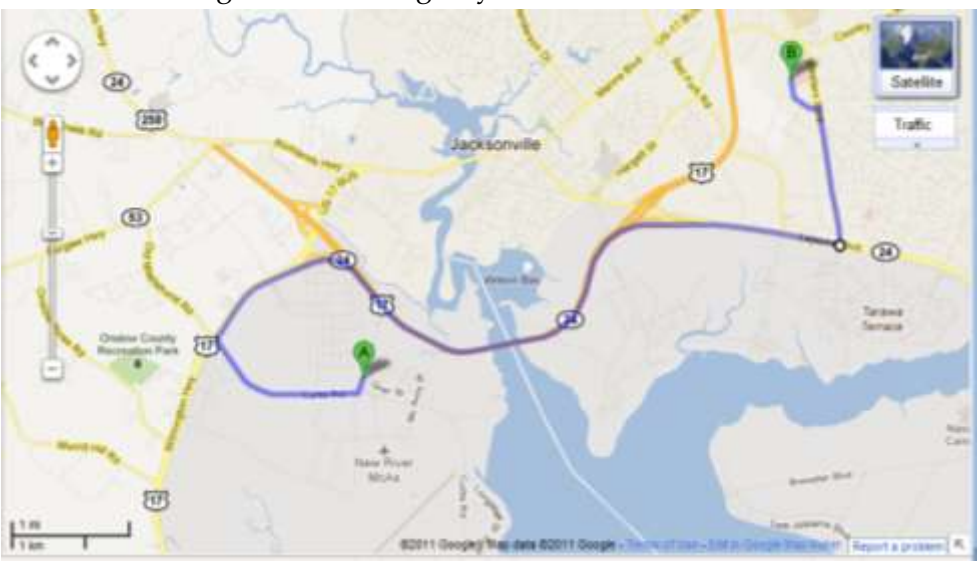
Base Ambulance: (910) 451-3004, (910) 451-3005

Public Ambulance: (910) 451-9111

From MCAS New River

Directions to Onslow County Memorial Hospital :

1. From Curtis Road, exit Base through Air Station main gate.
2. Turn Right onto US-17 N.
3. Merge onto NC Hwy 24 E/US-17 N.
4. Take the NC Hwy 24 exit toward Camp Lejeune/Morehead City/New Bern
5. Merge onto Lejeune Blvd.
6. Turn Right onto Western Blvd
7. The Onslow County Memorial Hospital is on the left, approximately 2 miles (fifth stop light) from Highway 24.
8. Follow the signs to the emergency room.



20.0 Spill Containment Procedures

CH2M HILL and subcontractor personnel working at the project site shall be knowledgeable of the potential health, safety and environmental concerns associated with petroleum and other substances that could potentially be released at the project site.

The following is a list of criteria that must be addressed in CH2M HILL's or the subcontractor's plans in the event of a spill or release. In the event of a large quantity spill notify emergency services. Personnel discovering a spill shall (only if safe to do so):

- Stop or contain the spill immediately (if possible) or note source. Shut off the source (e.g., pump, treatment system) if possible. If unsafe conditions exist, then leave the area, call emergency services, inform nearby personnel, notify the site supervisors, and initiate incident reporting process. The SC shall be notified immediately;
- Extinguish sources of ignition (flames, sparks, hot surfaces, cigarettes);
- Clear personnel from the spill location and barricade the area;
- Use available spill control equipment in an effort to ensure that fires, explosions, and releases do not occur, recur, or spread;
- Use sorbent materials to control the spill at the source;
- Construct a temporary containment dike of sorbent materials, cinder blocks, bricks or other suitable materials to help contain the spill;
- Attempt to identify the character, exact source, amount, and extent of the released materials. Identification of the spilled material should be made as soon as possible so that the appropriate cleanup procedure can be identified;
- Assess possible hazards to human health or the environment as a result of the release, fire or explosion; and
- Follow incident notification, reporting, and investigation section of this plan.

21.0 Inspections

21.1 Project Activity Self-Assessment Checklists

In addition to the hazard controls specified in this document, Project Activity Self-Assessment Checklists are contained as an attachment to this HSP. The Project-Activity Self–Assessment Checklists are based upon minimum regulatory compliance and some site-specific requirements may be more stringent. The objective of the self-assessment process is to identify gaps in project safety performance, and prompt for corrective actions in addressing these gaps. The self-assessment checklists, including documented corrective actions, shall be made part of the permanent project records and maintained by the SC.

The self-assessment checklists will also be used by the SC in evaluating the subcontractors and any client contractors' compliance on site.

The self-assessment checklists for the following tasks and exposures are required when the task or exposure is initiated and weekly thereafter while the task or exposure is taking place. The checklists shall be completed by the SC or other CH2M HILL representative and maintained in project files.

- Biological Prevention Measures
- Drilling
- LO/TO
- Hazardous Materials Handling
- Hand and Power Tools
- Lifting
- Vinyl Chloride

21.2 Safe Behavior Observations

Safe Behavior Observations (SBOs) are a tool to be used by supervisors to provide positive reinforcement for work practices performed correctly, while also identifying and eliminating deviations from safe work procedures that could result in a loss.

The SC or designee shall perform at least one SBO each week for any field work performed by subcontractors or when there are at least two CH2M HILL personnel performing field work.

The SC or designee shall complete the SBO form (attached to this HSP) for the task/operation being observed and submit them weekly.

For Federal projects, SBOs may be submitted electronically by e-mailing them to the address, "CH2M HILL ES FED Safe Behavior Observations" when connected to the network or at CH2MHILLESFEDSafeBehaviorObservation@ch2m.com.

22.0 Incident Notification, Reporting, and Investigation

(Reference CH2M HILL SOP HSE-111, *Incident Notification, Reporting and Investigation*)

22.1 General Information

This section applies to the following:

- All injuries involving employees, third parties, or members of the public;
- Damage to property or equipment;
- Interruptions to work or public service (hitting a utility);
- Incidents which attract negative media coverage;
- Near misses;
- Spills, leaks, or regulatory violations; and
- Motor vehicle accidents.

Documentation, including incident reports, investigation, analysis and corrective measure taken, shall be kept by the SC and maintained onsite for the duration of the project.

22.2 Section Definitions

Incident: An incident is an event that causes or could have caused undesired consequences. An incident may be caused by natural forces, employees, subcontractors, or third parties in any location associated with CH2M HILL operations, including offices, warehouses, project sites, private property, or public spaces. Incidents include:

- Injury or illness to a CH2M HILL employee or subcontractor employee, or member of the public;
- Property damage;
- Spill or release;
- Environmental requirement or permit violation;
- A "near-miss"; or
- Other (e.g., fire, explosion, bomb threat, workplace violence, threats)
- **Accident**: an incident involving actual loss through injury, damage to assets, or environmental harm.

Near Miss: A near-miss occurs when an intervening factor prevented an injury or illness, property damage, spill or release, permit violation or other event from occurring. Examples of near-miss situations include: a hard hat or other personal protective equipment (PPE) prevented an injury; secondary containment or emergency shutoff prevented a spill; or an alert co-worker prevented an incident.

Serious Incident:

A Serious Incident must be immediately reported to senior management includes:

- Work related death, or life threatening injury or illness of a CH2M HILL employee;
- subcontractor, or member of the public;
- Kidnap/missing person;

- Acts or threats of terrorism;
- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage; or
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment.

22.3 Reporting Requirements

All employees and subcontractors' employees shall immediately report any incident (including "near misses," as defined in the section above) in which they are involved or witness to their supervisor.

The CH2M HILL or Subcontractor supervisor, upon receiving an incident report, shall inform his immediate superior and the CH2M HILL SC.

The SC shall immediately report the following information to the RHSM and PM by phone and e-mail:
- Project Name and Site Manager;
- Date and time of incident;
- Description of incident;
- Extent of known injuries or damage;
- Level of medical attention; and
- Preliminary root cause/corrective actions

The RHSM shall immediately inform the EM (or available alternate) of spills, potential environmental permit compliance, or any environmental situation that could result in a notice of violation from an agency.

The CH2M HILL team shall comply with all applicable statutory incident reporting requirements such as those to OSHA, the police, or state or Federal environmental agency.

22.4 HITS System and Incident Report Form

CH2M HILL maintains a HITS entry and/or Incident Report Form (IRF) for all work-related injuries and illnesses sustained by its employees in accordance with recordkeeping and insurance requirements. A HITS entry and/or IRF will also be maintained for other incidents (property damage, fire or explosion, spill, release, potential violation, and near misses) as part of our loss prevention and risk reduction initiative.

The SC shall complete an entry into the Hours and Incident Tracking System (HITS) database system located on CH2M HILL's Virtual Office (or if VO not available, use the hard copy Incident Report Form and Root Cause Analysis Form and forward it to the RHSM) within 24 hours and finalize those forms within 3 calendar days.

22.5 Injury Management/Return-to-Work (for US/Puerto Rico based CH2M HILL Staff Only)

(Reference CH2M HILL, SOP HSSE-124, Injury Management/Return-to-Work)

22.5.1 Background

The Injury Management Program has been established to provide orderly, effective and timely medical treatment and return-to-work transition for an employee who sustains a work-related injury or illness. It also provides guidance and assistance with obtaining appropriate treatment to aid recovery, keep supervisors informed of employee status, and to quickly report and investigate work-related injury/illnesses to prevent recurrence.

To implement the Injury Management/Return-to-Work Program successfully, supervisors and/or SC should:

- Ensure employees are informed of the Injury Management/Return-to-Work Program;
- Become familiar with the Notification Process (detailed below); and
- Post the Injury Management/Return-to-Work Notification Poster.

22.5.2 The Injury Management/Return-to-Work Notification Process:

- Employee informs their supervisor.
- Employee calls the Injury Management Program toll free number 1-866-893-2514 immediately and speaks with the Occupational Injury Nurse. This number is operable 24 hours per day, 7 days a week.
- Supervisor ensures employee immediately calls the Injury Management Program number. Supervisor makes the call with the injured worker or for the injured worker, if needed.
- Nurse assists employee with obtaining appropriate medical treatment, as necessary schedules clinic visit for employee (calls ahead, and assists with any necessary follow up treatment). The supervisor or SC accompanies the employee if a clinic visit is necessary to ensure that employees receive appropriate and timely care.
- Supervisor or SC completes the HITS entry or Incident Report Form immediately (within 24 hours) and forwards it to the Project Manager and RHSM.
- Nurse notifies appropriate CH2M HILL staff by e-mail (supervisor, Health & Safety, Human Resources, Workers' Compensation).
- Nurse communicates and coordinates with and for employee on treatment through recovery.
- Supervisor ensures suitable duties are identified and available for injured or ill workers who are determined to be medically fit to return to work on transitional duty (temporary and progressive).
- Supervisor ensures medical limitations prescribed (if any) by physician are followed until the worker is released to full duty.

22.6 Serious Incident Reporting Requirements

(Reference CH2M HILL SOP HSE-111, *Incident Reporting, Notification and Investigation*)

The serious incident reporting requirements ensures timely notification and allows for positive control over flow of information so that the incident is handled effectively, efficiently, and in conjunction with appropriate corporate entities. This standard notification process integrates Health, Safety, Security and Environment and Firm Wide Security Operations requirements for the consistent reporting of and managing of serious events throughout our operations.

22.6.1 Serious Incident Determination

The following are general criteria for determining whether an incident on CH2M HILL owned or managed facilities or program sites is considered serious and must be immediately reported up to Group President level through the reporting/notification process:

- Work related death, or life threatening injury or illness of a CH2M HILL employee, subcontractor, or member of the public;
- Kidnap or missing person;
- Acts or threats of terrorism;

- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 in damage; or
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment.

22.6.2 Serious Incident Reporting

If an incident meets the "Serious Incident" criteria, the Project Manager is to immediately contact the Crisis Manager at 720-286-4911, then follow the standard incident reporting procedure.

For all serious incidents this standard reporting process is implemented immediately so as to ultimately achieve notification to the Business Group President within 2 hours of incident onset or discovery, and notification to appropriate corporate Crisis Management Support Team.

ESBG US Operations
Incident Reporting Flow Diagram

Direct Reporting Responsibility

Informational Reporting

Incident:

- Injury or illness
- Hazardous substance exposure
- Damage to property
- Fire or explosion
- Spill, release, potential violation, or permit exceedance
- A "near-miss"

If incident is an **injury** to US or Puerto Rico based CH2M HILL personnel contact the Occupational Health Nurse at 866/893-2514. Outside the US, the supervisor must notify the HR

The Ops Leader is responsible for completing the Incident Report Form (IRF) in **HITS** when there is an injury to a CH2M HILL employee. The PM, CM or SC is responsible for completing the IRF for all other incidents. ***The IRF/HITS must be completed within 24 hours of the incident and does not replace the required immediate PM and RHSM notifications.***

Incident

Ensure that Emergency Responders have been notified as necessary

Employee or Subcontractor

Provide immediate notification.

Supervisor – Construction Manager - Safety Coordinator

Provide immediate notification by phone and email to PM and RHSM. In addition, for spills, NOVs, and permit issues you may also call the EM.

CRISIS MANAGER:

If the incident meets the "**Serious Incident**" criteria, contact the Crisis Manager

(720.286.4911)

Third Party – Incidents outside of our contractual obligations do not need to be communicated, unless they are serious and/or may affect CH2M HILL. The RHSM will determine the level of communication necessary for third party incidents.

Serious Incident:

- Work related death, or life threatening injury or illness of a CH2M HILL employee, subcontractor, or member of the public
- Kidnap/missing person
- Acts or threats of terrorism
- Event that involves a fire, explosion, or property damage that requires a site evacuation or is estimated to result in greater than $ 500,000 US in damage.
- Spill or release of hazardous materials or substances that involves a significant threat of imminent harm to site workers, neighboring facilities, the community or the environment.

Responsible HSM (RHSM)

Immediately notify the Sector OR Client Program HSE Manager, immediately notify the Responsible Environmental Manager (EM) for spills, NOVs, and permit issues, and direct the incident investigation.

Client Program HSE Manager

Notify Sector HSM, and coordinate communication and incident investigations.

Immediate notification to the Sector HSM is not required for some minor incidents. Follow the program or sector protocol.

Sector HSE Manager

Coordinate communication, direct significant incident investigations, notify Sector EM for spills, NOVs, & permit issues.

HSSE Director

Provide decision-making assistance or direction for incident resolution.

Project Manager

Provide notification to the Sector OR Program Project Delivery (PD) or Operations (Ops) Manager or designee. Notification is based on program or sector specific criteria.

Immediate notification to the PD/Ops Manager is not required for some minor incidents. Follow the program or sector protocol.

Sector or Program PD/Ops Manager

Notify Client Program Manager OR Sector Director, provide guidance and follow the incident through to resolution.

Client Program Manager

Notify Sector Director; provide decision-making assistance or direction for incident resolution.

Keep unnecessary communication of serious incidents to a minimum.

Sector Director

Provide decision-making assistance or direction for incident resolution.

ES US Operations Director/ Executive Leadership Team

Provide decision-making assistance, direction for incident resolution, and make higher level notifications as necessary

Post-emergency incident communications regarding serious incidents at a CH2M HILL office or project (regardless of the party involved) shall be considered sensitive in nature and must be controlled in a confidential manner.

22.7 Incident Root Cause Analysis

The accident analysis is essential if all causes of the incident are to be identified for the correct remedial actions to be taken to prevent the same and similar type of incident from recurring. Root Cause Analysis (RCA) shall be completed for all recordable injuries, property damage incidents in excess of $5000.00 (US), environmental permit violations, spills and releases which are required to be reported to regulatory agencies, and any other incident, including near misses where they RHSM or PM determines an RCA is appropriate. The RHSM/REM is responsible for ensuring it is completed and results entered in the incident report form in HITS. RCA's must be completed using a Team that includes, at least the RHSM or designee, the involved party(ies), a responsible operations representative (e.g. PM, construction manager, crew supervisor, etc.) and an independent management representative not associated with the incident.

The Root Cause Analysis Form must be completed for all Loss Incidents and Near Loss Incidents. This form must be submitted to the investigation team for review.

For minor losses or near losses, the information may be gathered by the supervisor or other personnel immediately following the loss. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the loss, determine the root cause, and develop recommendations. More complex situations may require the investigation team to revisit the loss site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

Photographs or videotapes of the scene and damaged equipment should be taken from all sides and from various distances. This point is especially important when the investigation team will not be able to review the loss scene.

The investigation team must follow the Root Cause Analysis Flow Chart (see Attachment 4 of the SOP) to assist in identifying the root cause(s) of a loss. Any loss may have one or more root causes and contributing factors. The root cause is the primary or immediate cause of the incident, while a contributing factor is a condition or event that contributes to the incident happening, but is not the primary cause of the incident. Root causes and contributing factors that relate to the person involved in the loss, his or her peers, or the supervisor should be referred to as "personal factors." Causes that pertain to the system within which the loss or injury occurred should be referred to as "job factors."

Personal factors include:

- Lack of skill or knowledge;
- Correct way takes more time and/or requires more effort;
- Short-cutting standard procedures is positively reinforced or tolerated; or
- Person thinks there is no personal benefit to always doing the job according to standards.

Job Factors include:

- Lack of or inadequate operational procedures or work standards;
- Inadequate communication of expectations regarding procedures or standards; or
- Inadequate tools or equipment.

The root cause(s) could be any one or a combination of these seven possibilities or some other uncontrollable factor. In the vast majority of losses, the root cause is very much related to one or more of these seven factors. Uncontrollable factors should be used rarely and only after a thorough review eliminates all seven other factors.

22.7.1 Corrective Actions

Include all corrective actions taken or those that should be taken to prevent recurrence of the incident. Include the specific actions to be taken, the employer and personnel responsible for implementing the actions, and a timeframe for completion. Be sure the corrective actions address the causes.

Once the investigation report has been completed, the PM shall hold a review meeting to discuss the incident and provide recommendations. The responsible supervisors shall be assigned to carry out the recommendations, and shall inform the SC upon successful implementation of all recommended actions.

- Evaluation and follow-up of the IRF will be completed by the type of incident by the RHSM, EM, or FWSO.
- Incident investigations must be initiated and completed as soon as possible but no later than 72 hours after the incident.

23.0 Records and Reports

An organized project filing system is essential for good documentation and recordkeeping. There are many benefits to an organized filing system:

- Other CH2M HILL employees can easily and quickly find documents;
- Records are readily available for review;
- Records may be needed during OSHA investigations, audits, or other legal matters;
- Records may be needed on short notice in case of an accident, illness or other emergency; and
- Systematic recordkeeping aids in overall project organization.

The project filing system shall be established at the beginning of the project and maintained throughout all phases of construction and archived in accordance with CH2M HILL's Records Retention Policy. The information contained in the filing system shall be updated regularly and/or as specified in this document. The PM and SC are responsible for collecting documentation, including subcontractor documentation, and maintaining a complete and organized filing system.

Below are examples of records that must be maintained as the project progresses:

- Exposure records includes air monitoring data (including calibration records), MSDSs, exposure modeling results;
- Physical hazard exposure records include noise, ionizing radiation, non-ionizing radiation, vibration, and lasers exposure assessments and measurements;
- Respiratory fit test records;
- Training records;
- Incident reports, investigations and associated back-up information such as agency notifications, calculations, and corrective actions taken;
- Federal or state agency inspection records;
- Other Records:
  - Ergonomic evaluations;
  - HSE audits and assessments;
  - Project-specific HSE plans;
  - Confined space entry permits;
  - Equipment inspections;
  - Equipment maintenance;
  - Emergency equipment inspection records;
  - SBOs;
  - Self-assessment checklists
- The RHSM shall coordinate with the PM or designee to ensure that final project-specific HSE records described in this section, including negative exposure determinations, are maintained with the project files in accordance with the CH2M HILL records retention schedule, or forwarded to the Medical Surveillance Program Administrator, as appropriate. Records retention requirements are detailed in the Recordkeeping and Access to Records SOP, HSE-119.

CH2M HILL Health and Safety Plan

Attachment 1

Health and Safety Plan Employee Sign-off Form

EMPLOYEE SIGNOFF FORM

Health and Safety Plan

The CH2M HILL project employees and subcontractors listed below have been provided with a copy of this HSP, have read and understood it, and agree to abide by its provisions.

Project Name: Site 89 Monitoring Well Installation and Sampling **Project Number:** 423868

EMPLOYEE NAME (Please print)	EMPLOYEE SIGNATURE	COMPANY	DATE

CH2M HILL Health and Safety Plan

Attachment 2

Chemical Inventory/Register Form

CH2MHILL

CHEMICAL INVENTORY/REGISTER FORM

Refer to SOP HSE-107, Attachment 1, for instructions on completing this form.

Location:

HCC:

☐ Office ☐ Warehouse ☐ Laboratory ☐ Project:

Project No.:

Regulated Product	Location	Container labeled (✓if yes)	MSDS available (✓if yes)

MSDS for the listed products will be maintained at:

CH2M HILL Health and Safety Plan

Attachment 3

Chemical-Specific Training Form

CH2MHILL

CHEMICAL-SPECIFIC TRAINING FORM

Refer to SOP HSE-107 Attachment 1 for instructions on completing this form.

Location:	Project # :
HCC:	Trainer:

TRAINING PARTICIPANTS:

NAME	SIGNATURE	NAME	SIGNATURE

REGULATED PRODUCTS/TASKS COVERED BY THIS TRAINING:

The HCC shall use the product MSDS to provide the following information concerning each of the products listed above.

☐ Physical and health hazards

☐ Control measures that can be used to provide protection (including appropriate work practices, emergency procedures, and personal protective equipment to be used)

☐ Methods and observations used to detect the presence or release of the regulated product in the workplace (including periodic monitoring, continuous monitoring devices, visual appearance or odor of regulated product when being released, etc.)

Training participants shall have the opportunity to ask questions concerning these products and, upon completion of this training, will understand the product hazards and appropriate control measures available for their protection.

Copies of MSDSs, chemical inventories, and CH2M HILL's written hazard communication program shall be made available for employee review in the facility/project hazard communication file.

CH2M HILL Health and Safety Plan

Attachment 4

Project Activity Self-Assessment Checklists/Permits/Forms

Biological Prevention Measures
Drilling
Forklifts
Electrical
Hand and Power Tools
Hazardous Materials Handling
Lockout/Tagout
Manual Lifting
Traffic Control
Vinyl Chloride

HS&E Self-Assessment Checklist—Biological Prevention Measures

CH2MHILL

HS&E Self-Assessment Checklist

This checklist shall be used by Navy CLEAN personnel and shall be completed by each crew entering the work area at the frequency of one per day or otherwise specified in the project's Health and Safety Plan/Field Safety Instruction (HSP/FSI). The checklist should be completed prior to entry and at the end of the day to document that appropriate checks have been completed.

This checklist is to be used at locations where the possibility exists that contact with biological hazards is possible.

Site Safety Coordinator (SSC) will request any CH2M HILL subcontractor to take necessary precautions in eliminating the exposure to biological hazards, but shall not direct the means and methods.

Project Name: _____ Project No.: _____
Location: _____ PM: _____
Auditor: _____ Title: _____ Date: _____

- Check "Yes" if an assessment item is complete or correct.
- Check "No" if an item is incomplete or deficient. Section 2 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

SECTION 1 – PRE-ENTRY	Yes	No	N/A	N/O
SITE HAZARD EVALUATION				
1. Inform field members of hazards (types, symptoms)	☐	☐	☐	☐
2. Can work be completed without entering the work zone	☐	☐	☐	☐
3. Have controls been implemented where possible (clearing vegetation, spraying)	☐	☐	☐	☐
4. Has an inspection been made to identify nests, hives or areas where insects may concentrate	☐	☐	☐	☐
5. Will working at different time will reduce exposure	☐	☐	☐	☐
SENSATIVITIES				
6. Does any staff have existing reactions to stings or bites	☐	☐	☐	☐
7. If yes to #6, is special required and medication available on site (epi-pen)	☐	☐	☐	☐
8. Has anyone with an existing condition briefed other team members about symptoms and first aid which may be required	☐	☐	☐	☐
EMERGENCY RESPONSE				
9. Are first aid kits, along with tick removal kits, readily available to all staff	☐	☐	☐	☐
10. Does each member of the field staff have ability to communicate (phone, radios, and visual)	☐	☐	☐	☐
11. Are emergency contacts available (base emergency, local police, or local EMT	☐	☐	☐	☐
12. If working in remote areas, is transport readily available (less than 5 minutes)	☐	☐	☐	☐
13. Have you planned an emergency exit from the site in the event of a swarm	☐	☐	☐	☐

SECTION 2 - PPE	Yes	No	N/A	N/O
SELECTION OF PPE				
14. Will weather (heat, rain, ice) impact the safety of workers wearing protective suits	☐	☐	☐	☐
15. Will visibility be limited to unacceptable levels if a hood is worn	☐	☐	☐	☐
16. Will the use of equipment be difficult if a suit is worn	☐	☐	☐	☐
17. Will heavy vegetation be encountered that could rip or damage a suit	☐	☐	☐	☐
18. Will a Bug-Out suit or Tyvek suit be used by staff (if not, please give additional rationale in writing in Section 4)	☐	☐	☐	☐
TYPE OF PPE USED OTHER THAN BUG-OUT OR TYVEK SUIT				
19. Is staff wearing light-colored clothes	☐	☐	☐	☐
20. Is staff wearing long sleeve shirts	☐	☐	☐	☐
21. Are pant legs tucked into socks	☐	☐	☐	☐
22. Are shirts tucked into pants	☐	☐	☐	☐
23. Has tape been placed around sock/pant leg line and around waist	☐	☐	☐	☐
24. Have hand and wrist areas been sealed	☐	☐	☐	☐
25. Are hats being worn	☐	☐	☐	☐
26. Have clothes been pre treated with Permethrin	☐	☐	☐	☐
27. Has team member inspected coworker's suits or clothing to ensure no spaces exist for insects to penetrate	☐	☐	☐	☐

SECTION 3 – CHECKS AND DECONTAMINATION	Yes	No	N/A	N/O
DAILY CHECKS (TO BE COMPLETED DURING AND AT END OF DAY)				
28. Were tick/insect checks performed during the day (if not, please provide reason in Section 4)	☐	☐	☐	☐
29. Was one unclothed tick check completed	☐	☐	☐	☐
30. Were ticks found on the outerwear (if yes, please note the number in Section 4)	☐	☐	☐	☐
31. Were ticks found inside the Bug-Out, Tyvek, or personal clothing	☐	☐	☐	☐
32. Were suits turned inside out and inspected prior to putting away	☐	☐	☐	☐
33. Were showers taken by field staff immediately upon arrive from the field	☐	☐	☐	☐
34. Were clothing placed in a garbage bag and sealed to prevent any insects from spreading	☐	☐	☐	☐
35. If ticks were found embedding in skin, were they properly removed and saved	☐	☐	☐	☐
36. Have vehicles been inspected for ticks on a daily basis and before the vehicle is turned in	☐	☐	☐	☐
REPORTING				
37. If a tick was found on your skin, could you tell where it entered so that it could be addressed	☐	☐	☐	☐
38. If a tick was found embedded, did you contact the PM, complete a HITS form and contact the Occupational Physician at 1-866-893-2514	☐	☐	☐	☐
39. Did you contact field staff on the project to provide potential corrective measures	☐	☐	☐	☐
40. Did you follow the IM/RTW procedure to ensure you received the proper medical attention (if not, provide an explanation in Section 4)	☐	☐	☐	☐

SECTION 4

Complete this section for all items where further information was requested in the previous sections.

Item #	Rationale	Corrected (either next day or intended on future projects)

CH2MHILL

HSE Self-Assessment Checklist - Drilling

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's written safety plan.

This checklist is to be used at locations where: 1) CH2M HILL employees are potentially exposed to drilling hazards, 2) CH2M HILL staff are providing support function related to drilling activities, and/or 3) CH2M HILL oversight of a drilling subcontractor is required.

Safety Coordinator may consult with drilling subcontractors when completing this checklist, but shall not direct the means and methods of drilling operations nor direct the details of corrective actions. Drilling subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately, or all exposed personnel shall be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposures to drilling hazards (complete Section 1).
☐ Evaluate CH2M HILL support functions related to drilling activities (complete Section 2)
☐ Evaluate a CH2M HILL subcontractor's compliance with drilling safety requirements (complete entire checklist).
Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the drilling subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in SOP HSE-204.

SECTION 1 - SAFE WORK PRACTICES (5.1)

	Yes	No	N/A	N/O
1. Personnel cleared during rig startup	☐	☐	☐	☐
2. Personnel clear while mast is being raised	☐	☐	☐	☐
3. Personnel clear of rotating parts	☐	☐	☐	☐
4. Personnel not positioned under hoisted loads	☐	☐	☐	☐
5. Loose clothing and jewelry removed	☐	☐	☐	☐
6. Smoking is prohibited around drilling operation	☐	☐	☐	☐
7. Personnel wearing appropriate personal protective equipment (PPE), per written plan	☐	☐	☐	☐
8. Personnel instructed not to approach equipment that has become electrically energized	☐	☐	☐	☐

SECTION 2 - SUPPORT FUNCTIONS (5.2)

AQUIFER DESIGNATIONS (5.2.1)

9. Aquifer designations determined and BGEM consulted when required.	☐	☐	☐	☐

LOCATION OF UTILITIES (5.2.2)

10. Location of underground utilities and structures identified	☐	☐	☐	☐
11. Power lines de-energized and grounded when safe distances cannot be maintained	☐	☐	☐	☐

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SECTION 2 (Continued)

	Yes	No	N/A	N/O
WASTE MANAGEMENT (5.2.3)				
12. Drill cuttings and purge water managed and disposed properly	☐	☐	☐	☐
13. Wastes generated evaluated for proper disposal	☐	☐	☐	☐
14. Appropriate decontamination procedures being followed, per project's written safety plan	☐	☐	☐	☐
DRILLING AT ORDNANCE EXPLOSIVES OR UNEXPLODED ORDNANCE SITES (5.2.4)				
15. MEC plan prepared and approved	☐	☐	☐	☐
16. MEC avoidance provided, routes and boundaries cleared and marked	☐	☐	☐	☐
17. Initial pilot hole established by UXO technician with hand auger	☐	☐	☐	☐
18. Personnel remain inside cleared areas	☐	☐	☐	☐
SECTION 3 - DRILLING SAFETY REQUIREMENTS (5.3)				
GENERAL (5.3.1)				
19. Only authorized personnel operating drill rigs	☐	☐	☐	☐
20. Daily safety briefing/meeting conducted with crew	☐	☐	☐	☐
21. Daily inspection of drill rig and equipment conducted before use	☐	☐	☐	☐
22. Good housekeeping maintained on and around rig	☐	☐	☐	☐
SAFETY EQUIPMENT (5.3.2)				
23. Safety-toed shoes/boots, hardhats, safety glasses, gloves and hearing protection are worn	☐	☐	☐	☐
24. Drill rig equipped with fire extinguisher	☐	☐	☐	☐
25. Air monitoring instruments provided when required	☐	☐	☐	☐
26. PPE for protection from chemical hazards is worn if required				
DRILL RIG PLACEMENT (5.3.3)				
27. Location of underground utilities and structures identified	☐	☐	☐	☐
28. Safe clearance distance maintained from overhead power lines	☐	☐	☐	☐
29. Drilling pad established, when necessary	☐	☐	☐	☐
30. Drill rig leveled and stabilized	☐	☐	☐	☐
31. Additional precautions taken when drilling in confined areas	☐	☐	☐	☐
DRILL RIG TRAVEL (5.3.4)				
28. Rig shut down and mast lowered and secured prior to rig movement	☐	☐	☐	☐
29. Tools and equipment secured prior to rig movement	☐	☐	☐	☐
30. Only personnel seated in cab are riding on rig during movement	☐	☐	☐	☐
31. Backup alarm or spotter used when backing rig	☐	☐	☐	☐
32. Spotter used when backing rig in tight or confined areas or when low clearances exist	☐	☐	☐	☐
33. Safe clearance distance maintained while traveling under overhead power lines	☐	☐	☐	☐
EMERGENCY – CONTACT WITH OVERHEAD OR UNDERGROUND ELECTRICAL LINES (5.3.5)				
34. Personnel understand emergency procedures in the event of contact with overhead or underground electrical lines	☐	☐	☐	☐
DRILL RIG OPERATION (5.3.6)				
35. Kill switch clearly identified and operational	☐	☐	☐	☐
36. All machine guards are in place	☐	☐	☐	☐
37. Rig ropes never wrapped around any part of the body	☐	☐	☐	☐
38. Pressurized lines and hoses secured to prevent whipping hazards	☐	☐	☐	☐
39. Drilling operation stopped during inclement weather	☐	☐	☐	☐
40. Air monitoring conducted per written safety plan for hazardous atmospheres	☐	☐	☐	☐
41. Rig gear boxes placed in neutral when operator not at controls	☐	☐	☐	☐
42. Operator shuts rig engine down prior to leaving the drill rig vicinity	☐	☐	☐	☐

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DRILL RIG SITE CLOSURE (5.3.7)				
43. Ground openings/holes filled or barricaded	☐	☐	☐	☐
44. Equipment and tools properly stored	☐	☐	☐	☐
45. All vehicles locked and keys removed	☐	☐	☐	☐
DRILL RIG MAINTENANCE (5.3.8)				
46. Rig properly maintained per drilling company's maintenance program	☐	☐	☐	☐
47. Defective components repaired immediately	☐	☐	☐	☐
48. Lockout/tagout procedures used prior to maintenance	☐	☐	☐	☐
49. Cathead in clean, sound condition	☐	☐	☐	☐
50. Drill rig ropes in clean, sound condition	☐	☐	☐	☐
51. Fall protection used for fall exposures of 6 feet (U.S.) 1.5 meters (Australia) or greater	☐	☐	☐	☐
52. Rig in neutral and augers stopped rotating before cleaning	☐	☐	☐	☐
53. Good housekeeping maintained on and around rig	☐	☐	☐	☐
FORMS/PERMITS AND CHECKLISTS (7.0)				
54. Driller license/certification obtained	☐	☐	☐	☐
55. Well development/abandonment notifications and logs submitted and in project files	☐	☐	☐	☐
56. Groundwater withdrawal permit obtained where required	☐	☐	☐	☐
57. Dig permit obtained where required	☐	☐	☐	☐

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SECTION 4

Complete this section for all items checked "No" in previous sections. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

CH2MHILL

H&S Self-Assessment Checklist - FORKLIFTS

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where: 1) CH2M HILL employees are potentially exposed to hazards associated with forklift operations, 2) CH2M HILL employees are operating forklifts, and/or 3) CH2M HILL provides oversight of a subcontractor operating forklifts.

SC may consult with subcontractors using forklifts when completing this checklist, but shall not direct the means and methods of forklift operations nor direct the details of corrective actions. Subcontractors using forklifts shall determine how to correct deficiencies, and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposures to forklift hazards (Complete Section 1).
☐ Evaluate CH2M HILL employees operating forklifts (Complete entire checklist).
☐ Evaluate a CH2M HILL subcontractor's compliance with forklift safety requirements (Complete entire checklift).
Subcontractor's Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HS-48.

SAFE WORK PRACTICES (5.1) **SECTION 1**	**Yes**	**No**	**N/A**	**N/O**
1. Personnel maintaining safe distance from operating forklifts.	☐	☐	☐	☐
2. Positioning personnel in proximity to operating forklifts is avoided.	☐	☐	☐	☐
3. Personnel wearing high-visibility vests when close to operating forklifts.	☐	☐	☐	☐
4. Personnel approach operating forklifts safely.	☐	☐	☐	☐
5. Personnel only riding in seats equipped with seat belts.	☐	☐	☐	☐
6. Personnel not lifted or lowered by forklift unless approved for such use.	☐	☐	☐	☐
7. Personnel not positioned under elevated loads or forks.	☐	☐	☐	☐
8. Personnel do not place body between mast uprights or outside running lines during operation.	☐	☐	☐	☐
9. Personnel do not touch or approach forklift that has become electrically energized.	☐	☐	☐	☐

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FORKLIFT SAFETY REQUIREMENTS SECTION 2	Yes	No	N/A	N/O
PRIOR TO OPERATING FORKLIFT (5.2.1)				
10. Only certified personnel operating forklifts.	☐	☐	☐	☐
11. Daily safety briefing/meeting conducted with forklift operators.	☐	☐	☐	☐
12. Daily inspection of forklift conducted and documented.	☐	☐	☐	☐
13. Rated capacity of forklift visible to operator.	☐	☐	☐	☐
14. Modifications and attachments used approved by forklift manufacturer.	☐	☐	☐	☐
15. High-lift forklifts have load backrest and overhead guard.	☐	☐	☐	☐
16. Seat belts are provided and used.	☐	☐	☐	☐
17. Backup alarm or spotter used when backing forklift.	☐	☐	☐	☐
18. Operational horn provided and used as necessary.	☐	☐	☐	☐
19. Braking system capable of stopping capacity load.	☐	☐	☐	☐
20. Forklifts equipped with lights for low-light operations.	☐	☐	☐	☐
21. Carbon monoxide concentrations below PEL (50 ppm).	☐	☐	☐	☐
22. At least one fire extinguisher available at the forklift operating area.	☐	☐	☐	☐
DESIGNATIONS AND LOCATIONS (5.2.2)				
23. Atmosphere/locations classified as hazardous or non-hazardous.	☐	☐	☐	☐
24. Only properly designated forklifts used in hazardous locations.	☐	☐	☐	☐
FORKLIFT LOADING/UNLOADING (5.2.3)				
25. Operator handles only loads within rated capacity, adjusts for long or tall loads.	☐	☐	☐	☐
26. Loads are stabilized before forklift travel.	☐	☐	☐	☐
27. Operator using proper tilt to stabilize load, uses caution when tilting elevated loads.	☐	☐	☐	☐
28. When two forklifts lift a load in unison, operators stay in close communication.	☐	☐	☐	☐
29. Trucks, trailers, railroad cars secured from movement before entering with forklift.	☐	☐	☐	☐
30. Dockplates/bridgeplates secured before use; capacity not exceeded.	☐	☐	☐	☐
31. Truck, trailer, railroad car flooring checked for weakness before forklift boarding.	☐	☐	☐	☐
32. Personnel platforms secured to forklift and shut off means provided on platform.	☐	☐	☐	☐
FORKLIFT TRAVEL (5.2.4)				
33. Forklift operated on safe roadways and grades.	☐	☐	☐	☐
34. Grades ascended/descended properly.	☐	☐	☐	☐
35. Forklift operated at safe speed, kept under control at all times	☐	☐	☐	☐
36. Operators slow down and use horn at areas with obstructed vision.	☐	☐	☐	☐
37. Forklifts operating in reverse when load obstructs vision.	☐	☐	☐	☐
38. Operator keeping clear view of path of travel.	☐	☐	☐	☐
39. Forklifts do not pass other stopped vehicles at areas with obstructed vision.	☐	☐	☐	☐
40. Operators maintain safe distance from edge of ramps and platforms.	☐	☐	☐	☐
41. Overhead clearance maintained from installations.	☐	☐	☐	☐
42. Forklifts not parked within 8 feet of center of railroad tracks. Tracks crossed diagonally.	☐	☐	☐	☐
43. Forklift parked correctly when operator is dismounted.	☐	☐	☐	☐
FORKLIFT MAINTENANCE (5.2.5)				
44. Forklifts with unsafe conditions removed from service and tagged as such to prevent use.	☐	☐	☐	☐
45. Forklifts repaired in designated, non-hazardous locations by authorized personnel.	☐	☐	☐	☐
46. Battery disconnected when repairing electrical systems.	☐	☐	☐	☐
47. Additions or omissions of parts not performed without manufacturer's approval.	☐	☐	☐	☐
48. Good housekeeping maintained on and around forklift.	☐	☐	☐	☐
49. Water mufflers checked daily, kept at 75% full.	☐	☐	☐	☐
50. Forklifts removed from service if sparks, flames, or elevated operating temperatures occur.	☐	☐	☐	☐
51. Suspended forklifts or components are supported prior to work under or between.	☐	☐	☐	☐
52. Fueling/battery charging conducted in designated, well-ventilated area.	☐	☐	☐	☐
53. Fueling/battery charging areas properly equipped for task.	☐	☐	☐	☐
54. No smoking in fueling/battery charging areas.	☐	☐	☐	☐
55. Spillage of fuel properly cleaned up before starting forklift.	☐	☐	☐	☐

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SECTION 3

Complete this section for all items checked "No" in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

CH2MHILL

HSE Self-Assessment Checklist—HAND AND POWER TOOLS

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where: (1) CH2M HILL employees are exposed to hand and power tool hazards and/or (2) CH2M HILL provides oversight of subcontractor personnel who are exposed to hand and power tool hazards.

SC may consult with subcontractors when completing this checklist, but shall not direct the means and methods of hand and power tool use nor direct the details of corrective actions. Subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposure to hand and power tool hazards.
☐ Evaluate a CH2M HILL subcontractor's compliance with hand and power tool requirements.
Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-210.

SECTION 1

	Yes	No	N/A	N/O
SAFE WORK PRACTICES (5.1)				
1. All tools operated according to manufacturer's instructions and design limitations.	☐	☐	☐	☐
2. All hand and power tools maintained in a safe condition and inspected and tested before use.	☐	☐	☐	☐
3. Defective tools are tagged and removed from service until repaired.	☐	☐	☐	☐
4. PPE is selected and used according to tool-specific hazards anticipated.	☐	☐	☐	☐
5. Power tools are not carried or lowered by their cord or hose.	☐	☐	☐	☐
6. Tools are disconnected from energy sources when not in use, servicing, cleaning, etc.	☐	☐	☐	☐
7. Safety guards remain installed or are promptly replaced after repair.	☐	☐	☐	☐
8. Tools are stored properly.	☐	☐	☐	☐
9. Cordless tools and recharging units both conform to electrical standards and specifications.	☐	☐	☐	☐
10. Tools used in explosive environments are rated for such use.	☐	☐	☐	☐
11. Knife or blade hand tools are used with the proper precautions.	☐	☐	☐	☐
12. Consider controls to avoid muscular skeletal, repetitive motion, and cumulative trauma stressors.	☐	☐	☐	☐

CH2MHILL

HSE Self-Assessment Checklist—HAND AND POWER TOOLS

SECTION 2	Yes	No	N/A	N/O
GENERAL (5.2.2)				
13. PPE is selected and used according to tool-specific hazards anticipated.	☐	☐	☐	☐
14. Tools are tested daily to assure safety devices are operating properly.	☐	☐	☐	☐
15. Damaged tools are removed from service until repaired.	☐	☐	☐	☐
16. Power operated tools designed to accommodate guards have guards installed.	☐	☐	☐	☐
17. Rotating or moving parts on tools are properly guarded.	☐	☐	☐	☐
18. Machines designed for fixed locations are secured or anchored.	☐	☐	☐	☐
19. Floor and bench-mounted grinders are provided with properly positioned work rests.	☐	☐	☐	☐
20. Guards are provided at point of operation, nip points, rotating parts, etc.	☐	☐	☐	☐
21. Fluid used in hydraulic-powered tools is approved fire-resistant fluid.	☐	☐	☐	☐
ELECTRIC-POWERED TOOLS (5.2.3)				
22. Electric tools are approved double insulated or grounded and used according to SOP HSE-206.	☐	☐	☐	☐
23. Electric cords are not used for hoisting or lowering tools.	☐	☐	☐	☐
24. Electric tools are used in damp/ wet locations are approved for such locations or GFCI installed.	☐	☐	☐	☐
25. Hand-held tools are equipped with appropriate on/off controls appropriate for the tool.	☐	☐	☐	☐
26. Portable, power-driven circular saws are equipped with proper guards.	☐	☐	☐	☐
ABRASIVE WHEEL TOOLS (5.2.4)				
27. All employees using abrasive wheel tools are wearing eye protection.	☐	☐	☐	☐
28. All grinding machines are supplied with sufficient power to maintain spindle speed.	☐	☐	☐	☐
29. Abrasive wheels are closely inspected and ring-tested before use.	☐	☐	☐	☐
30. Grinding wheels are properly installed.	☐	☐	☐	☐
31. Cup-type wheels for external grinding are protected by the proper guard or flanges.	☐	☐	☐	☐
32. Portable abrasive wheels used for internal grinding are protected by safety flanges.	☐	☐	☐	☐
33. Safety flanges are used only with wheels designed to fit the flanges.	☐	☐	☐	☐
34. Safety guards on abrasive wheel tools are mounted properly and of sufficient strength.	☐	☐	☐	☐
PNEUMATIC-POWERED TOOLS (5.2.5)				
35. Tools are secured to hoses or whip by positive means to prevent disconnection.	☐	☐	☐	☐
36. Safety clips or retainers are installed to prevent attachments being expelled.	☐	☐	☐	☐
37. Safety devices are installed on automatic fastener feed tools as required.	☐	☐	☐	☐
38. Compressed air is not used for cleaning unless reduced to < 30 psi, with PPE, and guarded.	☐	☐	☐	☐
39. Manufacturer's safe operating pressure for hoses, pipes, valves, etc. are not exceeded.	☐	☐	☐	☐
40. Hoses are not used for hoisting or lowering tools.	☐	☐	☐	☐
41. All hoses >1/2-inch diameter have safety device at source to reduce pressure upon hose failure.	☐	☐	☐	☐
42. Airless spray guns have required safety devices installed.	☐	☐	☐	☐
43. Blast cleaning nozzles are equipped with operating valves, which are held open manually.	☐	☐	☐	☐
44. Supports are provided for mounting nozzles when not in use.	☐	☐	☐	☐
45. Air receiver drains, handholes, and manholes are easily accessible.	☐	☐	☐	☐
46. Air receivers are equipped with drainpipes and valves for removal of accumulated oil and water.	☐	☐	☐	☐
47. Air receivers are completely drained at required intervals.	☐	☐	☐	☐
48. Air receivers are equipped with indicating pressure gauges.	☐	☐	☐	☐
49. Safety, indicating, and controlling devices are installed as required.	☐	☐	☐	☐
50. Safety valves are tested frequently and at regular intervals to assure good operating condition.	☐	☐	☐	☐

SECTION 2 (continued)

	Yes	No	N/A	N/O
LIQUID FUEL-POWERED TOOLS (5.2.6)				
51. Liquid fuel-powered tools are stopped when refueling, servicing, or maintaining.	☐	☐	☐	☐
52. Liquid fuels are stored, handled, and transported in accordance with SOP HSE-403	☐	☐	☐	☐
53. Liquid fuel-powered tools are used in confined spaces in accordance with SOP HSE-203.	☐	☐	☐	☐
54. Safe operating pressures of hoses, valves, pipes, filters, and other fittings are not exceeded.	☐	☐	☐	☐
POWDER-ACTUATED TOOLS (5.2.7)				
55. Only trained employee operates powder-actuated tools.	☐	☐	☐	☐
56. Powder-actuated tools are not loaded until just prior to intended firing time.	☐	☐	☐	☐
57. Tools are not pointed at any employee at any time.	☐	☐	☐	☐
58. Hands are kept clear of open barrel end.	☐	☐	☐	☐
59. Loaded tools are not left unattended.	☐	☐	☐	☐
60. Fasteners are not driven into very hard or brittle materials.	☐	☐	☐	☐
61. Fasteners are not driven into easily penetrated materials unless suitable backing is provided.	☐	☐	☐	☐
62. Fasteners are not driven into spalled areas.	☐	☐	☐	☐
63. Powder-actuated tools are not used in an explosive or flammable atmosphere.	☐	☐	☐	☐
64. All tools are used with correct shields, guards, or attachments recommended by manufacturer.	☐	☐	☐	☐
JACKING TOOLS (5.2.8)				
65. Rated capacities are legibly marked on jacks and not exceeded.	☐	☐	☐	☐
66. Jacks have a positive stop to prevent over-travel.	☐	☐	☐	☐
67. The base of jacks are blocked or cribbed to provide a firm foundation, when required.	☐	☐	☐	☐
68. Wood blocks are place between the cap and load to prevent slippage, when required.	☐	☐	☐	☐
69. After load is raised, it is cribbed, blocked, or otherwise secured immediately.	☐	☐	☐	☐
70. Antifreeze is used when hydraulic jacks are exposed to freezing temperatures.	☐	☐	☐	☐
71. All jacks are properly lubricated.	☐	☐	☐	☐
72. Jacks are inspected as required.	☐	☐	☐	☐
73. Repair or replacement parts are examined for possible defects.	☐	☐	☐	☐
74. Jacks not working properly are removed from service and repaired or replaced.	☐	☐	☐	☐
HAND TOOLS (5.2.9)				
75. Wrenches are not used when jaws are sprung to the point of slippage.	☐	☐	☐	☐
76. Impact tools are kept free of mushroomed heads.	☐	☐	☐	☐
77. Wooden handles of tools are kept free of splinters or cracks and are tightly fitted in tool.	☐	☐	☐	☐

CHAIN SAWS (5.2.10)	Yes	No	N/A	N/O
78. Chainsaw equipped with spark arrestor and fully functioning chain brake	☐	☐	☐	☐
79. Chainsaw operator's manual readily available	☐	☐	☐	☐
80. Fully stocked first aid kit and multipurpose fire extinguisher available	☐	☐	☐	☐
81. Appropriate personal protective equipment available and worn	☐	☐	☐	☐
82. Clothing free of loose edges that could become entangled in the saw	☐	☐	☐	☐
83. Chainsaw handles kept dry, clean, and free of oil or fuel mixture	☐	☐	☐	☐
84. Chainsaws held firmly with both hands and used right-handed	☐	☐	☐	☐
85. Operator standing to the left of the saw out of the plane of the chain	☐	☐	☐	☐
86. Saw used between the waist and mid-chest level	☐	☐	☐	☐
87. Full throttle maintained while cutting	☐	☐	☐	☐
88. Operator aware of position of guide bar tip, does not contact tip with anything being cut	☐	☐	☐	☐
89. Bumper spikes maintained as close to the object as possible	☐	☐	☐	☐
90. Operator aware of what is in the saw's downward path after the cut	☐	☐	☐	☐
91. No attempt to made to cut material that is larger than the guide bar of the saw	☐	☐	☐	☐
92. Cuts avoided that will cause chain to jam	☐	☐	☐	☐
93. Non-metallic wedges used to prevent compression cuts from jamming the blade	☐	☐	☐	☐
94. Bystanders and helpers kept at a safe distance from operation	☐	☐	☐	☐
95. Chainsaw not operated when fatigued	☐	☐	☐	☐
96. Fire extinguisher present when operating the chainsaw in forest or brushy areas	☐	☐	☐	☐

CH2MHILL

HS&E Self-Assessment Checklist: HAZARDOUS MATERIALS

This checklist is provided as a method of verifying compliance with regulations pertaining to the handling of hazardous materials. It shall be used at locations where CH2M HILL employees handle hazardous materials, or are required to perform oversight of subcontractor personnel handling hazardous materials, or both.

CH2M HILL staff shall not direct the means and methods of subcontractor operations nor direct the details of corrective actions. The subcontractor must determine how to correct deficiencies, and CH2M HILL staff must carefully rely on the subcontractor's expertise. Items considered imminently dangerous (possibility of serious injury or death) must be corrected immediately, or all exposed personnel must be removed from the hazard until it is corrected.

Completed checklists must be sent to the appropriate regional health and safety program manager for review.

Project Name: _____ Project No.: _____
Location: _____ PM: _____
Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to (check only one of the boxes below):

☐ Evaluate CH2M HILL compliance with hazardous material handling requirements (SOP HSE-403)
☐ Evaluate a CH2M HILL subcontractor‟s compliance with hazardous material requirements
Subcontractor‟s Name: _____

- Check "Yes" if an assessment item is complete or correct.
- Check "No" if an item is incomplete or deficient. Section 2 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-403.

SECTION 1	Yes	No	N/A	N/O
PROCEDURES FOR HAZARDOUS MATERIAL HANDLING (6.0)				
GENERAL GUIDELINES (6.1)				
1. Acids are stored away from bases.	☐	☐	☐	☐
2. Oxidizers and organics are stored away from inorganic reducing agents.	☐	☐	☐	☐
3. Flammables and corrosives are stored in appropriate storage cabinets.	☐	☐	☐	☐
4. Paper and other combustibles are not stored near flammables.	☐	☐	☐	☐
5. Secondary containment and lipped shelving are in place in storage areas.	☐	☐	☐	☐
6. A fire suppression system is available.	☐	☐	☐	☐
SPILL CONTROL/CLEANUP (6.2)				
7. Spill control materials are located on the project site.	☐	☐	☐	☐
HAZARDOUS CHEMICAL INVENTORY REPORTING (6.3)				
8. Reporting is required if the project site handles and stores 10,000 lb or more of a hazardous chemical.	☐	☐	☐	☐
9. Or 500 lb or the threshold planning quantity (TPQ) of an extremely hazardous substance.	☐	☐	☐	☐
10. Regional ECC has been consulted for hazardous chemical inventory reporting.	☐	☐	☐	☐
TOXIC CHEMICAL RELEASE REPORTING				
11. Reporting requirements for toxic chemical release reporting have been followed.	☐	☐	☐	☐

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SECTION 1 (continued)	Yes	No	N/A	N/O
FLAMMABLE AND COMBUSTIBLE LIQUIDS (6.5)				
GENERAL STORAGE (6.5.1)				
12. Only approved containers/portable tanks used to store flammable and combustible liquids.	☐	☐	☐	☐
13. Approved safety cans used for handling flammable liquids in quantities 1-5 gallons.	☐	☐	☐	☐
14. For quantities of one gallon or less, the original container must be used for storage.	☐	☐	☐	☐
15. Flammable or combustible liquids are not stored in stairways or personnel passageways.	☐	☐	☐	☐
INDOOR STORAGE (6.5.2)				
16. Quantities of flammable or combustible liquids > 25 gallons stored in approved storage cabinet.	☐	☐	☐	☐
17. No more than 25 gallons of flamm. or comb. liquids can be stored outside an approved cabinet.	☐	☐	☐	☐
18. Cabinets are labeled with "„FLAMMABLE: KEEP FIRE AWAY."	☐	☐	☐	☐
19 No more than 60 gallons of flamm. or 120 gallons of comb. liquids stored in one storage cabinet.	☐	☐	☐	☐
20. Not more than three cabinets located in a single storage area.	☐	☐	☐	☐
OUTSIDE STORAGE (6.5.3)				
21. Storage of containers (not more than 60 gallons each) do not exceed 1,100 gallons in any area.	☐	☐	☐	☐
22. Storage areas are not within 20 feet of any building.	☐	☐	☐	☐
23. Storage areas graded to divert spills away from buildings and surrounded by an earth dike.	☐	☐	☐	☐
24. Storage areas are free from weeds, debris, and other combustible materials.	☐	☐	☐	☐
25. Outdoor portable tanks are provided with emergency vent devices.	☐	☐	☐	☐
26. Outdoor portable tanks are no closer than 20 feet from any building.	☐	☐	☐	☐
27. Signs indicating no smoking are posted around the storage area.	☐	☐	☐	☐
DISPENSING (6.5.4)				
28. Areas where liquids are dispensed in >5-gal quantities are separated from other operations by 25".	☐	☐	☐	☐
29. Drainage or other means provided to control spills.	☐	☐	☐	☐
30. Adequate natural or mechanical ventilation provided to maintain concentration of flammable vapor < 10% of the lower flammable limit.	☐	☐	☐	☐
31. Dispensing of flammable liquids from one container to another is done only when containers are electrically interconnected (bonded).	☐	☐	☐	☐
32. Dispensing flammable or combustible liquids by means of air pressure on the container or portable tanks prohibited.	☐	☐	☐	☐
33. Dispensing devices and nozzles for flammable liquids are of an approved type.	☐	☐	☐	☐
USE (6.5.5)				
34. Flammable liquids are kept in closed containers when not in actual use.	☐	☐	☐	☐
35. Leakage or spillage of flammable or combustible liquids is disposed of promptly and safely.	☐	☐	☐	☐
36. Sources of ignition are kept at least 50 feet from flammable liquids.	☐	☐	☐	☐
LIQUID PETROLEUM GAS (6.6)				
37. LPG containers meet DOT requirements.	☐	☐	☐	☐
38. Each container or system has a safety relief device or valve in good working order.	☐	☐	☐	☐
39. Portable heaters using LPG have an automatic shutoff device in the event of flame failure.	☐	☐	☐	☐
40. Storage of LPG within buildings is prohibited.	☐	☐	☐	☐
41. LPG storage location has at least one portable fire extinguisher rated not less than 20-B:C.	☐	☐	☐	☐

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SECTION 1 (continued)	Yes	No	N/A	N/O
COMPRESSED GAS CYLINDERS (6.7)				
GENERAL (6.7.1)				
42. Cylinders and apparatus inspected for defects and leakage prior to use. Damaged items not used.	☐	☐	☐	☐
43. Gas distributor notified and subsequent instructions followed for defective cylinders.	☐	☐	☐	☐
44. Leaking cylinders removed from the work area.	☐	☐	☐	☐
45. Cylinder users do not modify, tamper, or attempt repair on cylinders or apparatus.	☐	☐	☐	☐
46. Only cylinder owners or authorized agent refill cylinders or attempt to mix gases in a cylinder.	☐	☐	☐	☐
47. Cylinders labeled with the identity of the contents.	☐	☐	☐	☐
TRANSPORTING (6.7.2)				
48. Cylinders not rolled in the horizontal position or dragged; suitable material-handling device used.	☐	☐	☐	☐
49. Cylinders being transported have valve protection caps installed.	☐	☐	☐	☐
50. Cylinders in vertical position when transported by motor vehicle, hoisted, or carried.	☐	☐	☐	☐
51. Cylinders hoisted by a cradle or pallet designed for such use, and not by magnets, slings, or their valve protection caps.	☐	☐	☐	☐
STORAGE (6.7.3)				
52. Cylinders are stored in the vertical position with valve protection caps installed.	☐	☐	☐	☐
53. Cylinders are secured from being knocked over by a chain or other stabilizing device.	☐	☐	☐	☐
54. Cylinders are stored away from readily ignitable substances.	☐	☐	☐	☐
55. Cylinders are protected from exposure to temperature extremes.	☐	☐	☐	☐
56. Oxygen cylinders in storage are separated from fuel gas cylinders or combustible materials > 20" or by a ½-hour fire-resistant barrier at least 5" high.	☐	☐	☐	☐
57. Cylinders inside buildings are stored in dry, well-ventilated locations > 20" from comb. materials.	☐	☐	☐	☐
58. Cylinders are stored in definitely assigned places away from elevators, stairs, or gangways.	☐	☐	☐	☐
59. Signs indicating no smoking are provided for storage areas containing flammable gas cylinders.	☐	☐	☐	☐
PLACEMENT FOR USAGE (6.7.4)				
60. Cylinders are located where they will not be knocked over or damaged.	☐	☐	☐	☐
61. Cylinders are secured in the vertical position.	☐	☐	☐	☐
62. Cylinders are not placed where they can become part of an electrical circuit.	☐	☐	☐	☐
63. Cylinders are kept far enough away from welding and cutting operations to prevent sparks, hot slag, or flames from reaching them. When impractical, fire resistant shields are provided.	☐	☐	☐	☐
64. Cylinders are not taken into confined spaces.	☐	☐	☐	☐
CYLINDER CONNECTIONS (6.7.5)				
65. Pressure-controlling apparatus is compatible with the particular gas used.	☐	☐	☐	☐
66. Cylinders and pressure-controlling apparatus are kept free of oil and grease.	☐	☐	☐	☐
67. Pressure-controlling apparatus is kept gastight to prevent leakage.	☐	☐	☐	☐
68. Cylinders not attached to process where backflow could occur unless check valves or traps used.	☐	☐	☐	☐
69. Manifolds designed for product used at the appropriate temperatures, pressures, and flow rates.	☐	☐	☐	☐
70. Manifolds are labeled and placed in well-ventilated and accessible locations.	☐	☐	☐	☐
71. Cylinders are not cross-connected with plant air lines.	☐	☐	☐	☐
72. Flash arrestors or reverse flow check valves are installed on all flammable gas cylinders.	☐	☐	☐	☐
USAGE (6.7.6)				
73. Eye protection (safety glasses or goggles) is worn when using cylinders.	☐	☐	☐	☐
74. Cylinder valve and regulator are inspected for foreign material before connecting.	☐	☐	☐	☐
75. If cylinders are frozen, warm (not boiling) water is used to thaw cylinders.	☐	☐	☐	☐
76. Cylinder valve remains closed except when the cylinder is in use.	☐	☐	☐	☐
77. Fuel gas cylinder valves are not opened more than 1½ turns, for quick closing.	☐	☐	☐	☐
78. If a special wrench is used to open a cylinder valve, it is left in position on the valve.	☐	☐	☐	☐

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SECTION 1 (continued)	Yes	No	N/A	N/O
USAGE (continued) (6.7.6)				
79. Acetylene cylinders are used in the vertical position.	☐	☐	☐	☐
80. Acetylene cylinders are not used > 15 psig or > 30 psia.	☐	☐	☐	☐
81. Copper pipe or fittings are not used with acetylene systems.	☐	☐	☐	☐
82. Compressed gas is not used to dust off clothing.	☐	☐	☐	☐
83. Cylinder valve closed and regulator relieved of internal pressure before regulators are removed.	☐	☐	☐	☐
EXPLOSIVES (6.8)				
84. Written authorization provided by Munitions Market Segment Leader designating individuals who can store or use high explosives under the authority of the CH2M HILL BATF Type 33 User of High Explosives License/permit.	☐	☐	☐	☐
85. Written authorization provided by Munitions Market Segment Leader designating individuals who can manufacture high explosives under the authority of the CH2M HILL BATF Type 20 Manufacturer of High Explosives License/permit.	☐	☐	☐	☐
86. Approved Explosive Siting Plan (ESP).	☐	☐	☐	☐
87. Approved Explosive Management Plan (EMP).	☐	☐	☐	☐
88. Sources of ignition are not brought in or near storage magazines, or within 50" of an area where explosives are being handled, transported, or used.	☐	☐	☐	☐
89. Radio transmitting or receiving equipment is not brought within 1,000" of blasting activities.	☐	☐	☐	☐
90. Transportation and storage of explosives comply with local, state, and federal regulations.	☐	☐	☐	☐
91. Vehicles transporting explosives are placarded and displayed according to DOT regulations.	☐	☐	☐	☐
92. Detonators or blasting caps are not stored with explosive charges.	☐	☐	☐	☐
93. Explosives are stored in storage magazines as required by local, state, and federal regulations.	☐	☐	☐	☐
94. Contact the Munitions Response market Segment Leader for additional instructions	☐	☐	☐	☐
	☐	☐	☐	☐
PROCEDURES FOR HAZARDOUS MATERIALS SHIPPING (7.0)				
1. Only dangerous goods shippers are permitted to ship dangerous goods (CH2M HILL only).	☐	☐	☐	☐
2. Dangerous goods are shipped or transported in accordance with CH2M HILL"s procedures.	☐	☐	☐	☐
3. All personnel shipping dangerous goods have completed the computer-based training (CH2M HILL only)	☐	☐	☐	☐
4. Dangerous goods are stored only in the equipment warehouse prior to shipping.	☐	☐	☐	☐
5. Written authorization provided by Munitions Market Segment Leader designating individuals who can "offer explosives for shipment" under the authority of the CH2M HILL Department of Transportation Hazardous Materials Certificate of Registration				
SHIPPING BY AIR (7.1)				
5. Shipments for Federal Express meet IATA requirements for dangerous goods.	☐	☐	☐	☐
6. Before shipping, packages are clearly identified, packed, marked, labeled, and documented.	☐	☐	☐	☐
7. The quantity does not exceed IATA regulations.	☐	☐	☐	☐
8. Packaging meets IATA requirements and withstand transport by air.	☐	☐	☐	☐
9. Shipper classifies each item into one of the 9 hazard classes.	☐	☐	☐	☐
10. Inner packages are packed to prevent breaking or leaking during shipping.	☐	☐	☐	☐
11. Absorbent or cushioning material does not react with the contents of the inner package.	☐	☐	☐	☐
12. Outer packages in fiberboard, a plastic case, or other sturdy container.	☐	☐	☐	☐
13. Package is capable of withstanding 4" drop test with no damage.	☐	☐	☐	☐
14. Package is marked with: proper shipping name of contents, technical name, UN number, total net. quantity, and the name and address of the shipper and recipient.	☐	☐	☐	☐
15. Irrelevant labels have been removed from package.				
16. Hazard label and handling label are secured in correct locations.	☐	☐	☐	☐
17. Dangerous goods airbill has been completed.	☐	☐	☐	☐
18. Dangerous goods are not shipped via UPS.	☐	☐	☐	☐

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SECTION 1 (continued)

SHIPPING BY HIGHWAY (7.2)

	Yes	No	N/A	N/O
19. Use Federal Express packaging and paperwork requirements that comply with DOT regs for ground transportation of dangerous goods.	☐	☐	☐	☐
20. Consult with local state highway police if route includes vehicular tunnels.	☐	☐	☐	☐
21. Inner packaging prevents breakage or leakage under normal conditions of transport.	☐	☐	☐	☐
22. Absorbent/cushioning material does not react with contents of the package.	☐	☐	☐	☐
23. Labels for highway transportation are the same as those for air transportation.	☐	☐	☐	☐
24. Engine turned off, brake set during loading and unloading.	☐	☐	☐	☐

EMERGENCY RESPONSE (7.3)

	Yes	No	N/A	N/O
25. Appropriate emergency response information available not on the package, within reach of driver.	☐	☐	☐	☐
26. Information includes copy of pages from *Emergency Response Guidebook* for each item.	☐	☐	☐	☐
27. An MSDS for each item must also be included.	☐	☐	☐	☐
28. Emergency response information must also include the information found on the shipping papers.	☐	☐	☐	☐
29. CH2M HILL"s 24-hour EMERGENCY RESPONSE TELEPHONE NUMBER, (800) 255-3954, is included, as required.	☐	☐	☐	☐
30. In the event of an accident, keep other individuals, except response workers, from the vicinity.	☐	☐	☐	☐
31. In case of breakage, spillage, or leakage, use means to prevent spreading and contain the spill.	☐	☐	☐	☐
32. Care taken during the handling of cargo to minimize hazards.	☐	☐	☐	☐
33. MSDS is consulted for safe handling procedures.	☐	☐	☐	☐
34. Wash the area of the vehicle where the dangerous goods may have spilled.	☐	☐	☐	☐
35. Consult your supervisor in the event of a spill.	☐	☐	☐	☐
36. Ask your supervisor to call CHEM-TEL of the local HAZMAT unit if the spill poses a danger.	☐	☐	☐	☐

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SECTION 2

Complete this section for all items checked "No" in Section 1. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned or Taken	Date Corrected

CH2MHILL

HS&E Self-Assessment Checklist – LOCKOUT/TAGOUT

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's written safety plan.

This checklist is to be used when: 1) CH2M HILL staff are exposed to lockout/tagout hazards (complete Section 1), 2) CH2M HILL staff are self-performing lockout/tagout activities (completed Section 2), or 3) CH2M HILL provides oversight of subcontractor personnel who are performing lockout/tagout activities (complete Sections 1 and 2).

Safety Coordinator may consult with subcontractors when completing this checklist, but shall not direct the means and methods of lockout/tagout operations nor direct the details of corrective actions. Subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately, or all exposed personnel shall be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL affected employee exposure to equipment during lockout/tagout
☐ Evaluate CH2M HILL authorized employee exposure to equipment requiring lockout/tagout
☐ Evaluate a CH2M HILL subcontractor's compliance with lockout/tagout requirements
Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-33.

SECTION 1

SAFE WORK PRACTICES (5.4)

	Yes	No	N/A	N/O
1. Only trained and authorized personnel are performing lockout/tagout activities	☐	☐	☐	☐
2. All affected employees notified prior to lockout/tagout activities	☐	☐	☐	☐
3. Equipment has been shutdown using normal operating controls	☐	☐	☐	☐
4. Employees do not attempt to start, energize or use equipment that is locked out or tagged	☐	☐	☐	☐
5. Employees do not remove locks or tags placed on equipment by other personnel	☐	☐	☐	☐
6. Affected employees are notified after lockout/tagout is completed	☐	☐	☐	☐
7. Employees verify that all safe guards have been replaced prior to equipment start-up	☐	☐	☐	☐

SECTION 2	Yes	No	N/A	N/O
GENERAL (5.5.1)				
8. Only trained and authorized personnel are performing lockout/tagout activities	☐	☐	☐	☐
9. Daily safety briefing/meeting conducted with affected and authorized employees	☐	☐	☐	☐
10. Employees made aware of any equipment-specific lockout/tagout procedures	☐	☐	☐	☐
11. Authorized employees provided with lockout devices, locks, tags and other isolation devices	☐	☐	☐	☐
12. New or modified equipment designed to accept lockout devices	☐	☐	☐	☐
EQUIPMENT-SPECIFIC LOCKOUT/TAGOUT PROCEDURES (5.5.2)				
13. LOTO procedures available when required to be documented	☐	☐	☐	☐
14. Equipment-specific LOTO procedures developed when not available from the facility	☐	☐	☐	☐
15. Affected employees notified that equipment will be shut down for LOTO	☐	☐	☐	☐
16. Energy sources, hazards, and control measures determined	☐	☐	☐	☐
17. Orderly shutdown of equipment is conducted that does not increase hazards	☐	☐	☐	☐
18. Energy isolating devices operated to isolate energy sources	☐	☐	☐	☐
19. Authorized employees apply personal lockout devices and tags to energy isolating device	☐	☐	☐	☐
20. Lockout devices are applied to secure equipment in the "off" position	☐	☐	☐	☐
21. Lockout tags applied to clearly indicate that operating the equipment is prohibited	☐	☐	☐	☐
22. Tags are located as close to or at the energy isolating device	☐	☐	☐	☐
23. All hazardous stored or residual energy is relieved, disconnected or restrained.	☐	☐	☐	☐
24. Isolation of energy sources has been verified (tested) prior to of work on equipment	☐	☐	☐	☐
25. Lockout tags are used alone only where lockout devices cannot be applied	☐	☐	☐	☐
LOCKOUT DEVICES AND TAGS (5.5.4)				
26. Lockout devices and tags only used to isolate energy sources	☐	☐	☐	☐
27. Lockout devices and tags are standardized by color, shape, size, print, and format	☐	☐	☐	☐
28. Lockout devices and tags indicate identity of employee applying the devices	☐	☐	☐	☐
29. Lockout devices and tags capable of withstanding anticipated environmental conditions of use	☐	☐	☐	☐
30. Lockout devices are substantial enough to prevent removal without the use of excessive force	☐	☐	☐	☐
31. Tags and their means of attachment are substantial enough to prevent inadvertent removal	☐	☐	☐	☐
32. Tags are legible and understandable by all employees	☐	☐	☐	☐
33. Tags warn against hazardous conditions if equipment is energized	☐	☐	☐	☐
RELEASING LOTO CONTROL (5.5.5)				
34. Work area inspected prior to removing LOTO devices and reenergization	☐	☐	☐	☐
35. LOTO devices only removed by authorized employees who applied the device	☐	☐	☐	☐
36. If employee not available to remove LOTO devices, steps in Section 4.2.4 of SOP followed	☐	☐	☐	☐
37. All affected employees notified prior to starting equipment previously locked or tagged out	☐	☐	☐	☐
GROUP LOTO (5.5.6)				
38. Group LOTO procedures followed when more than one employees is to work on equipment	☐	☐	☐	☐
39. Primary authorized person assigned to coordinate LOTO process	☐	☐	☐	☐
40. Normal steps for initiating LOTO control completed as above	☐	☐	☐	☐
41. Primary authorized person applies own lockout device and tag	☐	☐	☐	☐
42. Each authorized person applies own lockout device and tag	☐	☐	☐	☐
43. Primary authorized person removes LOTO devices after all other LOTO devices are removed	☐	☐	☐	☐
SPECIAL CONDITIONS (5.5.7)				
44. Shift or personnel changes coordinated to ensure LOTO protection is always provided	☐	☐	☐	☐
45. Procedures followed when LOTO devices are temporarily removed to test or reposition	☐	☐	☐	☐

SECTION 3

Complete this section for all items checked "No" in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

CH2MHILL

HSE Self-Assessment Checklist—Lifting

This checklist shall be used **only** by CH2M HILL personnel and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where: (1) CH2M HILL employees perform manual lifting activities (office or projects), and/or (2) CH2M HILL provides oversight of a subcontractor performing manual lifting activities. SC or Office Safety Coordinators/Committee members may consult with subcontractors (if applicable) when completing this checklist but shall not direct the means and methods of activities nor direct the details of corrective actions. Subcontractors shall determine how to correct deficiencies, and we must carefully rely on their expertise. Conditions considered imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazardous area until corrected.
Complete the appropriate project or office information:

Project Information

Project Name: _____ Project No.: _____

Location: _____ PM: _____

Auditor: _____ Title: _____ Date: _____

Office Information

Office Location: _____

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee manual lifting activities.

☐ Evaluate a CH2M HILL subcontractor's manual lifting activities.
Subcontractor Name: _____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor.
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HSE-112.

Planning Activities	**Yes**	**No**	**N/A**	**N/O**
1. Efforts have been made to inquire about receiving equipment or supplies in containers weighting less than 50 pounds (23 kilograms).	☐	☐	☐	☐
2. Equipment or supplies are being delivered as close as possible to their use point.	☐	☐	☐	☐
3. Heavy equipment or supplies are being stored off the ground and no lower than knee height.	☐	☐	☐	☐
4. Adequate space has been provided to access and lift equipment or supplies without reaching or twisting.	☐	☐	☐	☐

Safe Work Practices (5.1)	**Yes**	**No**	**N/A**	**N/O**
5. Tasks or activities have been modified to reduce or minimize manual lifting.	☐	☐	☐	☐
6. All employees performing manual lifting have received training on how to lift safely.	☐	☐	☐	☐

7. Manual lifting control measures are evaluated during assessments.	☐	☐	☐	☐
8. Manual lifting incidents are reviewed as part of the HSE Program reviews.	☐	☐	☐	☐
9. Manual lifting incidents are reviewed as part of the HSE Program reviews.	☐	☐	☐	☐
Office Environments (5.1.1)	**Yes**	**No**	**N/A**	**N/O**
10. Employees have received lifting training.	☐	☐	☐	☐
11. Mechanical devices are readily available to employees handling equipment or supplies weighing more than 40 pounds (18 kilograms).	☐	☐	☐	☐
Field Projects (5.1.2)	**Yes**	**No**	**N/A**	**N/O**
12. All manual lifting tasks or activities have been addressed in the written site safety plan.	☐	☐	☐	☐
13. Employees have received safe lifting training as required by the written site safety plan.	☐	☐	☐	☐
Mechanical Lifting (5.2)	**Yes**	**No**	**N/A**	**N/O**
14. Hand trucks and trolleys are visually inspected before use.	☐	☐	☐	☐
15. Hand trucks and trolleys do not have any broken or damaged parts.	☐	☐	☐	☐
16. Hand truck and trolley paths are free of uneven surfaces, water, oil, or cracks and holes.	☐	☐	☐	☐
17. Loads carried by hand trucks are balanced and sturdy.	☐	☐	☐	☐
18. Hand trucks or dollies are being pushed when on level ground.	☐	☐	☐	☐
19. When going up or down a slope using a hand truck or trolley, the load is downslope of the person.	☐	☐	☐	☐
20. Employees using hand trucks or dollies are moving slowly and cautiously.	☐	☐	☐	☐
21. Employees using hand trucks or trolleys are able to see over the load.	☐	☐	☐	☐
Assisted Lifting (5.3)	**Yes**	**No**	**N/A**	**N/O**
22. Personnel are not performing manual lifting beyond their physical capabilities.	☐	☐	☐	☐
23. Loads are evenly distributed when being handled by multiple people.	☐	☐	☐	☐
Manual Lifting (5.4)	**Yes**	**No**	**N/A**	**N/O**
24. Before the lift, the load and path was assessed.	☐	☐	☐	☐
25. Loads being lifted are free of sharp edges, slivers, or wet or greasy spots.	☐	☐	☐	☐
26. Gloves are used for manual lifts of loads with sharp or splintered edges.	☐	☐	☐	☐
27. Employees performing manual lifts use the proper lifting techniques.	☐	☐	☐	☐
28. Special tools fabricated for lifting grates or manhole covers are used.	☐	☐	☐	☐

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: _____ Project Manager: _____

CH2MHILL

HS&E Self-Assessment Checklist -Vinyl Chloride

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI. This checklist is to be used at locations where CH2M HILL employees are exposed to vinyl chloride, or are required to perform oversight of a subcontractor whose personnel are exposed to vinyl chloride.

CH2M HILL staff shall not direct the means and methods of subcontractor vinyl chloride activities nor direct the details of appropriate corrective actions. The subcontractor must determine how to correct deficiencies and CH2M HILL staff must carefully rely on their expertise. Conditions considered to be imminently dangerous (possibility of serious injury or death) must be corrected immediately or all exposed personnel must be removed from the hazard until corrected.

Project Name: _____ Project No.: _____

Location: _____ PM:

Auditor: _____ Title: _____ Date: _____

This specific checklist has been completed to:

☐ Evaluate CH2M HILL compliance with its Vinyl Chloride program (SOP HSE-512)

☐ Evaluate a CH2M HILL subcontractor's compliance with its Vinyl Chloride program

Subcontractors Name: _____

- Check "Yes" if an assessment item is complete/correct
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable
- Check "N/O" if an item is applicable but was not observed during the assessment

SECTION 1

	Yes	No	N/A	N/O
PERSONNEL SAFE WORK PRACTICES (5.1)				
COMPLIANCE PROGRAM (5.1.1)				
1. A written compliance program is established for work above the PEL.	☐	☐	☐	☐
2. The compliance program includes means of maintaining exposures below the PEL	☐	☐	☐	☐
3. The compliance program is based on the most recent air monitoring results.	☐	☐	☐	☐
4. Written compliance program is available to all affected employees.	☐	☐	☐	☐
5. Waste generated must be determined if considered hazardous waste.	☐	☐	☐	☐
EMPLOYEE INFORMATION (5.1.2)				
6. CH2M HILL personnel have completed the Vinyl Chloride Training Module.	☐	☐	☐	☐
7. Training on the Fact Sheet, HSP/FSI and OSHA standard has been met.	☐	☐	☐	☐
8. The selection of the appropriate respirator is based on the airborne vinyl concentration.	☐	☐	☐	☐
9. Written or verbal notification to owners, contractors or other personnel working in the area of vinyl chloride work activities.	☐	☐	☐	☐
10. Storage, waste or shipping containers have been properly labeled	☐	☐	☐	☐

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	Yes	No	N/A	N/O
REGULATED AREAS (5.1.3)				
11. Areas that exceed the PELs (TWA or STEL) have been designated as regulated areas.	☐	☐	☐	☐
12. Personnel do not enter regulated areas unless they meet training, medical and PPE requirements	☐	☐	☐	☐
13. Warning signs have been posted at all entrances to the regulated areas.	☐	☐	☐	☐
Exposure Assessment (5.2)				
14. Initial air monitoring (TWA & STEL) conducted over full shift for each job classification	☐	☐	☐	☐
15. Air monitoring has been repeated when a change in production or controls occurred.	☐	☐	☐	☐
16. Personnel exhibiting signs of exposure have been monitored.	☐	☐	☐	☐
17. EL> AL have been resampled in the last 6 months.	☐	☐	☐	☐
18. EL $\geq$ PEL have been resampled in the 3 months.	☐	☐	☐	☐
19. Air monitoring results above the STEL have been resampled according to frequency established by RHSM.	☐	☐	☐	☐
20. Employees are given opportunities to observe monitoring	☐	☐	☐	☐
21. Relevant employees are notified within 15 days in writing of the results of monitoring.	☐	☐	☐	☐
CONTROL METHODS (5.3)				
ENGINEERING AND WORK PRACTICE CONTROLS (5.3.1)				
22. Engineering controls and work practices are implemented to reduce exposures to below the PEL.	☐	☐	☐	☐
23. Engineering and work practices are implemented to achieve the lowest feasible exposures.	☐	☐	☐	☐
24. Employees are not allowed to eat, drink or smoke in regulated areas.	☐	☐	☐	☐
25. Action plans have been developed to respond to spills.	☐	☐	☐	☐
26. Employees responding to spills have been trained and supplied with PPE	☐	☐	☐	☐
27. Vinyl chloride-contaminated waste is properly handled.	☐	☐	☐	☐
RESPIRATORY PROTECTION (5.3.2)				
28. Respirators are used in areas where EL $\geq$ PEL.	☐	☐	☐	☐
29. A written respiratory protection program is in place where respirators are used.	☐	☐	☐	☐
30. Cartridges changed based on change schedule or at the beginning of each shift.	☐	☐	☐	☐
Personal Protective Equipment (5.3.3)				
31. PPE is provided by the employer at no cost to employees.	☐	☐	☐	☐
32. PPE is selected based on the materials, conditions, and hazards present.	☐	☐	☐	☐
33. PPE is provided clean and dry for each use	☐	☐	☐	☐
34. Personnel who clean or launder protective clothing are informed in writing of the hazards.	☐	☐	☐	☐

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SECTION 3

Complete this section for all items checked "No' in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

CH2M HILL Health and Safety Plan

Attachment 5

Key Target Zero Program Elements

Activity Hazard Analysis

Pre-Task Safety Plans

Safe Behavior Observation

Incident Report and Investigation
(use electronic form when possible)
HITS

Lessons Learned Template

ACTIVITY HAZARD ANALYSIS

Activity:	**Date**:
	Project Name:
Description of the work:	**Site Supervisor**:
	Site Safety Officer:
	Review for latest use: Before the job is performed

Work Activity Sequence (Identify the principal steps involved and the sequence of work activities)	**Potential Health and Safety Hazards** (Analyze each principal step for potential hazards)	**Hazard Controls** (Develop specific controls for each potential hazard)

ACTIVITY HAZARD ANALYSIS

Work Activity Sequence (Identify the principal steps involved and the sequence of work activities)	**Potential Health and Safety Hazards** (Analyze each principal step for potential hazards)	**Hazard Controls** (Develop specific controls for each potential hazard)

Equipment to be used (List equipment to be used in the work activity)	**Inspection Requirements** (List inspection requirements for the work activity)	**Training Requirements** (List training requirements including hazard communication)

ACTIVITY HAZARD ANALYSIS

	PRINT NAME	SIGNATURE	
Supervisor Name:	_____	_____	Date/Time:_____
Safety Officer Name:	_____	_____	Date/Time:_____
Employee Name(s):	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____
	_____	_____	Date/Time:_____

CH2MHILL

Pre-Task Safety Plan (PTSP) and Safety Meeting Sign-in Sheet

Project:_____ Location: _____ Date:_____

Supervisor: _____ Job Activity:_____

_____

Attendees: Print Name Sign Name

_____

_____

_____

_____

_____

_____

_____

List Tasks and verify that applicable AHAs have been reviewed:

_____

_____

_____

Tools/Equipment Required for Tasks (ladders, scaffolds, fall protection, cranes/rigging, heavy equipment, power tools):

_____

_____

_____

Potential H&S Hazards, including chemical, physical, safety, biological and environmental (check all that apply):

__ Chemical burns/contact	__ Trench, excavations, cave-ins	__ Ergonomics
__ Pressurized lines/equipment	__ Overexertion	__ Chemical splash
__ Thermal burns	__ Pinch points	__ Poisonous plants/insects
__ Electrical	__ Cuts/abrasions	__ Eye hazards/flying projectile
__ Weather conditions	__ Spills	__ Inhalation hazard
__ Heights/fall > 6 feet	__ Overhead Electrical hazards	__ Heat/cold stress
__ Noise	__ Elevated loads	__ Water/drowning hazard
__ Explosion/fire	__ Slips, trip and falls	__ Heavy equipment
__ Radiation	__ Manual lifting	__ Aerial lifts/platforms
__ Confined space entry	__ Welding/cutting	__ Demolition
__Underground Utilities	__ Security	__ Poor communications

Other Potential Hazards (Describe):

_____

_____

_____

Hazard Control Measures (Check All That Apply):			
PPE __ Thermal/lined __ Eye __ Dermal/hand __ Hearing __ Respiratory __ Reflective vests __ Flotation device __ Hard Hat	Protective Systems __ Sloping __ Shoring __ Trench box __ Barricades __ Competent person __ Locate buried utilities __ Daily inspections __ Entry Permits/notification	Fire Protection __ Fire extinguishers __ Fire watch __ Non-spark tools __ Grounding/bonding __ Intrinsically safe equipment	Electrical __ Lockout/tagout __ Grounded __ Panels covered __ GFCI/extension cords __ Power tools/cord inspected __ Overhead line clearance __ Underground utils ID'd
Fall Protection __ Harness/lanyards __ Adequate anchorage __ Guardrail system __ Covered opening __ Fixed barricades __ Warning system	Air Monitoring __ PID/FID __ Detector tubes __ Radiation __ Personnel sampling __ LEL/O2 __ No visible dust __ Other	Proper Equipment __ Aerial lift/ladders/scaffolds __ Forklift/heavy equipment __ Backup alarms __ Hand/power tools __ Crane with current inspection __ Proper rigging __ Operator qualified	Welding & Cutting __ Cylinders secured/capped __ Cylinders separated/upright __ Flash-back arrestors __ No cylinders in CSE __ Flame retardant clothing __ Appropriate goggles
Confined Space Entry __ Isolation __ Air monitoring __ Trained personnel __ Permit completed __ Rescue	Medical/ER __ First-aid kit __ Eye wash __ FA-CPR trained personnel __ Route to hospital	Heat/Cold Stress __ Work/rest regime __ Rest area __ Liquids available __ Monitoring __ Training	Vehicle/Traffic __ Traffic control __ Barricades __ Flags __ Signs
Permits __ Hot work __ Confined space __ Lockout/tagout __ Excavation __ Demolition __ Energized work	Demolition __ Pre-demolition survey __ Structure condition __ Isolate area/utilities __ Competent person __ Hazmat present	Inspections: __ Ladders/aerial lifts __ Lanyards/harness __ Scaffolds __ Heavy equipment __ Drill rigs/geoprobe rigs __ Cranes and rigging __ Utilities marked	Training: __ Hazwaste (current) __ Construction __ Competent person __ Task-specific __ FA/CPR __ Confined Space __ Hazcom
Underground Utilities __Dig alert called __3rd Party locater __As-builts reviewed __Interview site staff __Client review __soft locate necessary?	Incident Communications __Work stops until cleared by TM/CM __Immediate calls to TM/CM __Client notification __24 hour notification setup __Clear communications	AHA' s __reviewed and approved by HSM __on site and current __applicable for this day's work __Communication and incident processes included?	

Field Notes (including observations from prior day, etc.):
_____
_____
_____

Name (Print): _____
Signature:_____ Date:_____

CH2MHILL

Safe Behavior Observation Form		
☐Federal or ☐Commercial Sector (check one)	☐Construction or ☐Consulting (check one)	
Project Number:	Client/Program:	
Project Name:	Observer:	Date:
Position/Title of worker observed:	Background Information/ comments:	
Task/Observation Observed:		

- ❖ Identify and reinforce safe work practices/behaviors
- ❖ Identify and improve on at-risk practices/acts
- ❖ Identify and improve on practices, conditions, controls, and compliance that eliminate or reduce hazards
- ❖ Proactive PM support facilitates eliminating/reducing hazards (do you have what you need?)
- ❖ Positive, corrective, cooperative, collaborative feedback/recommendations

Actions & Behaviors	Safe	At-Risk	Observations/Comments
Current & accurate Pre-Task Planning/Briefing (Project safety plan, STAC, AHA, PTSP, tailgate briefing, etc., as needed)			**Positive Observations/Safe Work Practices:**
Properly trained/qualified/experienced			
Tools/equipment available and adequate			
Proper use of tools			**Questionable Activity/Unsafe Condition Observed:**
Barricades/work zone control			
Housekeeping			
Communication			
Work Approach/Habits			
Attitude			
Focus/attentiveness			**Observer's Corrective Actions/Comments:**
Pace			
Uncomfortable/unsafe position			
Inconvenient/unsafe location			
Position/Line of fire			
Apparel (hair, loose clothing, jewelry)			
Repetitive motion			**Observed Worker's Corrective Actions/Comments:**
Other…			

For ES Federal Sector projects please email completed forms to: CH2M HILL ES FED Safe Behavior Observation
For ES Commercial Sector projects please email completed forms to: CH2M HILL ES COM Safe Behavior Observation
For CNR ES staff please email completed forms to: cnressafe@ch2m.com

HITS Incident Report Hardcopy (Phase 1 – Initial Entry)

Phase 1 – Initial Entry

Type of Incident (May select more than one)

☐ Injury/Illness ☐ Spill/Release ☐ Near Miss
☐ Property Damage ☐ Environment/Permit ☐ Other

General Information Section

Preparer's Name: _____ **Preparer's Phone Number:** _____

Date of Incident: _____ **Time of Incident**: _____ AM / PM

What Business Group is accountable for this incident: _____

What Business Group SubGroup is accountable for this incident: _____

What CH2M HILL Company is accountable for this incident: _____

Where did the Incident occur?

- ☐ United States, Geographic Region: _____
- ☐ Canada, Province/Territory: _____
- ☐ International, County: _____

Location of Incident?

- ☐ Company Premises, CH2M HILL Office (use 3 letter office code if available): _____
- ☐ Project, Project name: _____
- ☐ In Transit
  Traveling from: _____
  Traveling to: _____
- ☐ At Home
- ☐ Other, Specify: _____

Describe the incident: _____

_____

_____

Describe how this event could have been prevented: _____

_____

Provide Witness Information:

Name: _____ Phone: _____
Name: _____ Phone: _____
Name: _____ Phone: _____

Personnel Notified of Incident (Provide name, date and time):

CH2M HILL Personnel:

_____

Client Personnel:

_____

Additional Comments:

_____

_____

Injury/Illness Section **[Complete only if Injury/Illness Incident type selected]**

Who was injured?

- ☐ CH2M HILL Employee or CH2M HILL Temp Employee
- ☐ Subcontractor to CH2M HILL (Non-LLC Joint Venture Project)
- ☐ LLC Joint Venture Partner Employee
- ☐ LLC Joint Venture Project Subcontractor/Contractor
- ☐ Other

Name of Injured: _____ **Job Title:** _____

Employer Name: _____ **Supervisor of Employee:** _____

Complete for CH2M HILL Employee Injuries

Business Group of Injured Employee: _____

Has the employee called the Injury Management Administrator (1-800-756-1130)?

☐ Yes ☐ No ☐ Not Sure

Has the injured employee's supervisor been notified of this incident?

☐ Yes ☐ No ☐ Not Sure

Complete for Non-CH2M HILL Employee Injuries

Has the project safety coordinator been notified of this incident?

☐ Yes ☐ No ☐ Not Sure

Project Safety Coordinator: _____

Body Part Affected: _____

Injury/Illness (Result): _____

Describe treatment provided (if medication provided, identify whether over-the-counter or prescription): _____

_____

Describe any work restriction prescribed (include dates and number of days): _____

_____

Physician/Health Care Provider Information

Name: _____ Phone: _____

Was treatment provided away from the worksite?

☐ No

☐ Yes

Facility Name:

_____

Address:

_____

City: _____ Phone Number:

_____

Was injured treated in an emergency room?

☐ No ☐ Yes

Was injured hospitalized overnight as an in-patient?

☐ No ☐ Yes

General Information Environmental Section **[Complete only if Environment/Permit or Spill/Release Incident type selected]**

Who had control of the area during the incident?

☐ CH2M HILL, Company: _____

☐ Subcontractor, Company: _____

☐ Joint Venture Partner/Contractor/Subcontractor, Company: _____

☐ Other, Company: _____

Relationship to CH2M HILL: _____

Property Damage Section **[Complete only if Property Damage Incident type selected]**

Property Damaged: _____

Property Owner: _____

Damage Description: _____

Estimated US Dollar Amount: _____

Spill or Release Section **[Complete only if Spill/Release Incident type selected]**

Substance: _____

Estimated Quantity: _____

Did the spill/release move off the property?: _____

Spill/Release From: _____

Spill/Release To: _____

Environment/Permit Section **[Complete only if Environment/Permit Incident type selected]**

Describe Environmental or Permit Issue: _____

Permit Type: _____

Permitted Level or Criteria (e.g., discharge limit): _____

Permit Name and Number (e.g., NPDES No. ST1234): _____

Substance and Estimated Quantity: _____

Duration of Permit Exceedence: _____

HSSE

Lessons Learned

[Date] ESBG LL-11-xx

Subject	**[Insert Descriptive Name of Lessons Learned]**
CH2M HILL Project?	[Yes or No]
Situation	[Describe incident or situation that occurred in general terms. Try to be brief and avoid unnecessary details such as names of people or projects, business groups, divisions, dates, location, etc.]
Lessons Learned (Recommendations and Comments)	• Bullet out any lessons learned, recommendations or other important "take away" information that would benefit others. Tie the recommendations to the incident or event, and avoid including information that is not directly tied to the event.
Submitted By	[Name/Office Location/Phone]
Additional Information Contact	[Name/Office Location/Phone]
Keywords/Categories	[Insert any keywords or incident categories that would aid in a search for this lessons learned]

Send completed Lessons Learned to the ESBG HSSE Director for posting and distribution. Please include a recommended distribution list.

CH2M HILL Health and Safety Plan

Attachment 6

Fact Sheets

Tick Fact Sheet

Vehicle Accident Guidance

Working Alone

Tick-Borne Pathogens — A Fact Sheet

Most of us have heard of Lyme disease or Rocky Mountain Spotted Fever (RMSF), but there are actually six notifiable tick-borne pathogens that present a significant field hazard. In some areas, these account for more than half of our serious field incidents. The following procedures should be applied during any field activity—even in places that are predominantly paved with bordering vegetation.

Hazard Recognition

An important step in controlling tick related hazards is understanding how to identify ticks, their habitats, their geographical locations, and signs and symptoms of tick-borne illnesses.

Tick Identification

There are five varieties of hard-bodied ticks that have been associated with tick-borne pathogens. These include:

- Deer (Black Legged) Tick (eastern and pacific varieties)
- Lone Star Tick
- Dog Tick
- Rocky Mountain Wood Tick

These varieties and their geographical locations are illustrated on the following page.

Tick Habitat

In eastern states, ticks are associated with deciduous forest and habitat containing leaf litter. Leaf litter provides a moist cover from wind, snow, and other elements. In the north-central states, is generally found in heavily wooded areas often surrounded by broad tracts of land cleared for agriculture.

On the Pacific Coast, the bacteria are transmitted to humans by the western black-legged (deer) tick and habitats are more diverse. For this region, ticks have been found in habitats with forest, north coastal scrub, high brush, and open grasslands. Coastal tick populations thrive in areas of high rainfall, but ticks are also found at inland locations.

Illnesses and Signs & Symptoms

There are six notifiable tick-borne pathogens that cause human illness in the United States. These pathogens may be transmitted during a tick bite—normally hours after attachment. The illnesses, presented in approximate order of most common to least, include:

- Lyme (bacteria)
- RMSF (bacteria)
- Ehrlichiosis (bacteria)
- STARI (Southern Tick-Associated Rash Illness) (bacteria)
- Tularemia (Rabbit Fever) (bacteria)
- Babesia (protozoan parasite)

Symptoms will vary based on the illness, and may develop in infected individuals typically between 3 and 30 days after transmission. Some infected individuals will not become ill or may develop only mild symptoms. These illnesses present with some or all of the following signs & symptoms: fever, headache, muscle aches, stiff neck, joint aches, nausea, vomiting, abdominal pain, diarrhea, malaise, weakness, small solid, ring-like, or spotted rashes. The bite site may be red, swollen, or develop ulceration or lesions. For Lyme disease, the bite area will sometimes resemble a target pattern. A variety of long-term symptoms may result if the illness is left untreated, including debilitating effects and death.

Deer Tick

From Left: adult female, adult male, nymph, and larvae Deer Tick (cm scale)

Lone Star Tick

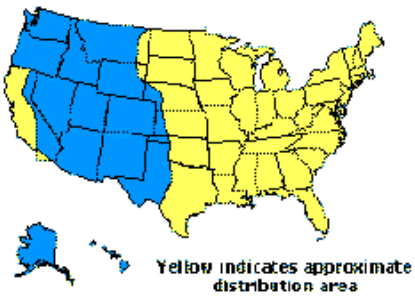
Dog Tick

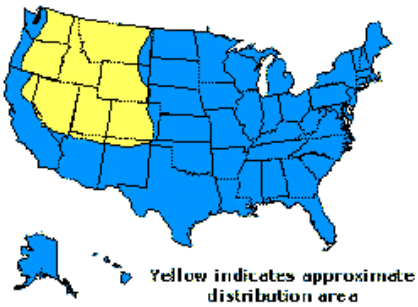
Rocky Mountain Wood Tick

Distribution of Deer Tick (dark green)

Distribution of Pacific Deer Tick (dark green)

Distribution of Lone Star Tick (Green)





Hazard Control

The methods for controlling exposure to ticks include, in order of most- to least-preferred:

- Avoiding tick habitats and ceasing operations in heavily infested areas
- Reducing tick abundance through habitat disruption or application of acracide
- Personal protection through use of repellants and protective clothing
- Frequent tick inspections and proper hygiene

Vaccinations are not available and preventative antibiotic treatment after a bite is generally not recommended.

Avoidance and Reduction of Ticks

To the extent practical, tick habitats should be avoided. In areas with significant tick infestation, consider stopping work and withdrawing from area until adequate tick population control can be achieved. Stopping and withdrawing should be considered as seriously as entering an area without proper energy control or with elevated airborne contaminants—tick-borne pathogens present risk of serious illness!

In areas where significant population density or infestation exists, tick reduction should be considered. Tick reduction can be achieved by disrupting tick habitats and/or direct population reduction through the use of tick-toxic pesticides (Damminix, Dursban, Sevin, etc.).

Habitat disruption may include only simple vegetative maintenance such as removing leaf litter and trimming grass and brush. Tick populations can be reduced by between 72 and 100 percent when leaf litter alone is removed. In more heavily infested areas, habitat disruption may include grubbing, tree trimming or removal, and pesticide application (Damminix, Dursban, Sevin, etc.). This approach is practical in smaller, localized areas or perimeter areas that require occasional access. Habitat controls are to be implemented with appropriate health and safety controls, in compliance with applicable environmental requirements, and may be best left to the property owner or tenant or to a licensed pesticide vendor. Caution should be exercised when using chemical repellents or pesticides in or around areas where environmental or industrial media samples will be collected for analysis.

Personal Protection

After other prevention and controls are implemented, personal protection is still necessary to control exposure to ticks. Personal protection must include all of the following steps:

- So that ticks may be easily seen, wear light-colored clothing. Full-body New Tyvek (paper-like disposable coveralls) may also be used
- To prevent ticks from getting underneath clothing tuck pant legs into socks or tape to boots
- Wear long-sleeved shirts, a hat, and high boots
- Apply DEET repellent to exposed skin or clothing per product label
- Apply permethrin repellent to the outside of boots and clothing before wearing, per product label
- Frequently check for ticks and remove from clothing
- At the end of the day, search your entire body for ticks (particularly groin, armpits, neck, and head) and shower
- To prevent pathogen transmission through mucous membranes or broken/cut skin, wash or disinfect hands and/or wear surgical-style nitrile gloves any time ticks are handled

Pregnant individuals and individuals using prescription medications should consult with their physician and/or pharmacists before using chemical repellents. Because human health effects may not be fully known, use of chemical repellents should be kept to a minimum frequency and quantity. Always follow manufacturers' use instructions and precautions. Wash hands after handling, applying, or removing

protective gear and clothing. Avoid situations such as hand-to-face contact, eating, drinking, and smoking when applying or using repellents.

Remove and wash clothes per repellent product label. Chemical repellents should not be used on infants and children.

Vaccinations are generally not available for tick-borne pathogens. Although production of the LYMErix™ Lyme disease vaccination has been ceased, vaccination may still be considered under specific circumstances and with concurrence from the consulting physician.

Tick Check

A tick check should be performed after field survey before entering the field vehicle (you do not want to infest your field vehicle with ticks). Have your field partner check your back; the backs of your legs, arms, and neck; and your hairline. Shake off clothing as thorough as possible before entering the vehicle. Once the field day is complete, repeat this procedure and perform a thorough self check.

If a tick has embedded itself into the skin, remove the tick as described below.

Tick Removal

1. Use the tick removal kit obtained through the CH2M HILL Milwaukee warehouse, or a fine-tipped tweezers or shield your fingers with a tissue, paper towel, or nitrile gloves.

2. Grasp the tick as close to the skin surface as possible and pull upward with steady, even pressure. Do not twist or jerk the tick; this may cause the mouthparts to break off and remain in the skin. If this happens, remove mouthparts with tweezers. Consult your healthcare provider if infection occurs.

3. Avoid squeezing, crushing or puncturing the body of the tick because its fluids (saliva, hemolymph, gut contents) may contain infectious organisms. Releasing these organisms to the outside of the tick's body or into the bite area may increase the chance of infectious organism transmission.

4. Do not handle the tick with bare hands because infectious agents may enter through mucous membranes or breaks in the skin. This precaution is particularly directed to individuals who remove ticks from domestic animals with unprotected fingers. Children, elderly persons, and immunocompromised persons may be at greater risk of infection and should avoid this procedure.

5. After removing the tick, thoroughly disinfect the bite site and wash your hands with soap and water.

6. Should you wish to save the tick for identification, place it in a plastic bag, with the date of the tick bite, and place in your freezer. It may be used at a later date to assist a physician with making an accurate diagnosis (if you become ill).

Note: Folklore remedies such as petroleum jelly or hot matches do little to encourage a tick to detach from skin. In fact, they may make matters worse by irritating the tick and stimulating it to release additional saliva, increasing the chances of transmitting the pathogen. These methods of tick removal should be avoided. In addition, a number of tick removal devices have been marketed, but none are better than a plain set of fine tipped tweezers.

First-Aid and Medical Treatment

Tick bites should always be treated with first-aid. Clean and wash hands and disinfect the bite site after removing embedded tick. Individuals previously infected with Lyme disease does not confer immunity—re-infection from future tick bites can occur even after a person has contracted a tick-borne disease.

The employee should contact the Injury Management/Return To Work provider (IMRTW), WorkCare using the toll-free number 866-893-2514 to report the tick bite. WorkCare will follow-up with each CH2M Hill employee who reports a tick bite and is at risk of developing Lyme disease by monitoring for symptoms up to 45 days, and will refer the employee to a medical provider for evaluation and treatment as necessary.

CH2MHILL

Enterprise Standard Operating Procedure HSE-512

Vinyl Chloride Fact Sheet

Uses and Occurrences—Polyvinyl chloride and copolymers, organic synthesis, adhesives for plastics, and as a precursor in the production of the common plastic polyvinyl chloride (PVC). It is often a degradation product of a number of chlorinated compounds, including tetra-chloroethylene and trichloroethylene, at hazardous waste sites in soils and groundwater. It can also be a breakdown product of the combustion of PVC or other chlorinated compounds.

Physical Characteristics

Appearance:	Colorless gas
Odor:	Sweet; Odor threshold: 3,000 ppm
Flammable:	Class IA Flammable Liquid Gas; NFPA Rating: 4
Flash Point:	-78 °C (-108°F)
Flammable Limits:	3.6% - 33.0% (% by volume in air)
Specific gravity:	0.91; (water = 1.0)
Stability:	Stable under ordinary conditions of use and storage
Vapor Pressure:	2300 mm Hg (at 20 °C)
Incompatibilities:	Atmospheric oxygen and strong oxidizers may react to produce peroxide, which can initiate a violent polymerization reaction
Melting Point:	-155.7 °C (-248°F)
Boiling Point:	-14 °C (7°F)

Signs and Symptoms of Exposure

Inhalation:	Short Term: Dizziness, light-headedness, nausea, dullness of visual and auditory responses, drowsiness, and unconsciousness Long Term: Thickening of skin, contact and allergic dermatitis, fatigue, coughing and sneezing, abdominal pain, gastrointestinal bleeding, nausea, vomiting, indigestion, diarrhea, jaundice, weight loss, anorexia, and cold and tingling sensations of the hands and feet, carcinogen.
Skin contact:	Short Term: Skin contact with liquid can cause frostbite. Long Term: Dermatitis
Eye contact:	Vapors can cause eye irritation. Contact can produce pain, inflammation and temporal eye damage.

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Modes of Exposure

Inhalation:	Vapor
Absorption:	Liquid causes frostbite
Ingestion:	Ingestion of contaminated water

Exposure Limits

Action level	0.5 ppm
PEL	1 ppm
STEL	None
PEL-C	5 ppm
TLV	1 ppm

Exposure Level vs. Regulatory Requirements

EXPOSURE LEVEL (EL)	REGULATORY REQUIREMENTS
EL < AL	Maintain exposure as low as reasonably achievable
EL > AL, EL < PEL	Implement portions of the OSHA Vinyl chloride standard and Training
EL > PEL	Implement all portions of the OSHA Vinyl Chloride Standard including training, medical surveillance, engineering controls, establishment of work areas, etc.

PPE

Eye:	Safety glasses, chemical goggles, face shield
Skin:	Tychem SL or other full-body clothing, depending on the exposure. Nitrile, Viton or laminated film gloves.
Respiratory:	Air purifying respirators and supplied air respirators, depending on the exposure.

First Aid

Inhalation:	Move to fresh air, begin rescue breathing if breathing has stopped and CPR if heart action has stopped, transfer promptly to a medical facility.
Skin:	Immerse affected part in warm water. Seek medical attention.
Eyes	Flush with large amounts of water for at least 15 minutes. Seek medical attention immediately.
Ingestion:	Contact a physician.

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2011 Vehicle Accident Guidance—ESBG

Remember that if you a **renting** a non-CH2M HILL owned vehicle (short-term rental) in the U.S., you should carry the insurance card from the state where your driver's license is issued.

If you operate a **fleet vehicle**, carry the insurance card where the vehicle is registered.

For ALL Vehicles if you are in an accident:

1. If you are injured, call 911 for emergency medical treatment or 1-866-893-2514 to contact the CH2M HILL Occupational Nurse/Physician for minor injuries. If you feel you have not been injured, contact the RHSM for guidance on whether calling the CH2M HILL Occupation Nurse/Physician is applicable.

2. **Call the Police--**For any vehicle accident/damage, it is recommended that the local police (or site security/emergency services if working on a client site that provides such services) be called to determine if a report needs to be filed. In some instances, a report may not be required (during accident alerts, or in public parking lots). Document that the authorities were called and follow up with any guidance they give you. State requirements vary. If a report is filed, obtain a copy.

3. Notify Supervisor, (and PM/RHSM if working on a project site)

4. Complete a HITS report on the VO.

Additional Steps

To report an auto accident, and before a claim can be taken by telephonic reporting, have available your name (the company name alone is no longer accepted, a driver's name must be provided even for fender benders), location of accident and your office address if different than the accident location, business group and project number. A claim cannot be taken without your name, address, business group and your project number. By location the state where the accident occurred, and which office you are aligned to, i.e., accident occurs in Idaho, but you are out of the Denver office. Advise the claim recorder the accident occurred in ID, but that your office location is Denver. This will assist the claim intake person in identifying location coding for the claims.

Auto accidents involve two different sections of an Auto policy:

1) Liability to others due to Bodily Injury and Property Damage

2) Physical Damage - Comprehensive and Collision - damage to the vehicle CH employee is driving

CH2M Hill has Liability coverage for any auto - our policy will respond on either a primary or excess basis.

Refer to the table below for additional notifications to make based on the type of accident experienced and type of vehicle being used.

Liability - Bodily Injury or Property Damage to Others

Scenario	Which Coverage Responds	What to do if in an accident
CH2M Hill fleet, pool or project vehicle - long term lease - lower 48	CH2M Hill - Primary	Contact Broadspire (1-800-753-6737); Jennifer Rindahl/DEN (720-286-2449); Linda George/DEN (720-286-2057)
CH2M Hill fleet, pool or project vehicle - long term lease - Alaska (North Slope)	CH2M Hill - Primary	Contact Jennifer Rindahl/DEN (720-286-2449)
Client vehicle driven by CH2M Hill employee	Client's auto policy unless client has made CH2M Hill responsible for vehicle	Contact Broadspire (1-800-753-6737); Contact Jennifer Rindahl/DEN (720-286-2449); contact client;
Short term lease (30 days or less)	Rental car company if rented through Enterprise, Budget or Hertz; CH2M Hill excess	Contact Broadspire (1-800-753-6737); Contact local branch of rental car company where vehicle leased (ERAC includes 24 hour roadside assistance) and Jennifer Rindahl/DEN (720-286-2449)
Short term lease (30 days or less)	CH2M Hill - Primary if rented through company other than our national agreements; $100,000 deductible	Contact Broadspire (1-800-753-6737); Contact rental car company and Jennifer Rindahl/DEN (720-286-2449)
Personal vehicle used on business	Employee's personal auto policy; CH2M Hill on an excess basis	Contact personal auto insurance company; contact Jennifer Rindahl/DEN (720-286-2449)

Physical Damage - damage to vehicle CH employee was driving

Scenario	Which Coverage Responds	What to do if in an accident
CH2M Hill fleet, pool or project vehicle - long term lease - lower 48	CH2M Hill ONLY if vehicle is scheduled on policy - $5,000 deductible	Contact Broadspire (1-800-753-6737); Jennifer Rindahl/DEN (720-286-2449); Linda George/DEN (720-286-2057)
CH2M Hill fleet, pool or project vehicle - long term lease - Alaska (North Slope)	CH2M Hill Equipment Schedule if scheduled on policy	Contact Jennifer Rindahl/DEN (720-286-2449)
CH2M Hill fleet, pool or project vehicle - long term lease	ARI if physical damage coverage purchased - $500 deductible	Contact Jennifer Rindahl/DEN 720.286.2449; call ARI at 1-800-221-1645 give them Client Code and ARI fleet vehicle number; and notify Linda George/DEN - Fleet Coordinator - 720-286-2057
Client vehicle CH2M Hill Employee is driving	Client's auto policy unless client has made CH2M Hill contractually responsible for vehicle	Contact Jennifer Rindahl/DEN (720-286-2449); contact client; contact Broadspire (1-800-753-6737)
Short term lease (30 days or less) using corporate VISA	VISA if corporate credit card used and vehicle is not a pickup, truck, cargo van or used off-road	Contact VISA - 1-800-847-2911 or http://www.visa.com/eclaim
Short term lease (30 days or less) through Enterprise (ERAC) and vehicle is used off-road and physical damage coverage included when vehicle leased	ERAC up to $3,000 in damage; CH2M Hill's coverage is excess	Notify Rental Car Company; contact Jennifer Rindahl/DEN (720-286-2449) if damage over $5,000
Short term lease (30 days or less) did **not** use corporate VISA	CH2M Hill - $5,000 deductible (project responsibility)	Contact Broadspire (1-800-753-6737); Contact Jennifer Rindhal/DEN 720-286-2449; contact VISA - 1-800-847-2911 or http://www.visa.com/eclaim
Personal vehicle used on business	CH will reimburse the amount of the deductible carried on the employee's policy up to $500 whichever is less	Contact Jennifer Rindahl/DEN (720-286-2449); contact client; contact Broadspire (1-800-753-6737)

Details for reporting a claim on the CH2M Hill VO are accessed by going to the VO home page and clicking:

GLOBAL ENTERPRISE SERVICES/INSURANCE & BONDING/CLAIMS REPORTING

HOW DO I REPORT A CLAIM TAB or access the following URL:

https://www.int.ch2m.com/intrnl/voffice/corp/insurance/claims/report.asp?Menu=menu3h

For Personally Owned Vehicles (POVs):

CH2M HILL does not provide auto insurance for POVs, it is responsibility of the owner. If you are in a vehicle accident conducting company business, contact the police as above, supervisor, and 911 or CH2M HILL's occupational nurse/physician as stated above. Complete a HITS report. Contact Jennifer Rindahl/DEN for assistance for meeting personal insurance deductibles (up to $500) with proof of insurance and deductible.

If using your POV for extended project use, notify the PM to make sure a rental car is not needed. Check your insurance policy for guidance on using the POV for business use.

Additional Resources:

Claims Resource Manual

WORKING ALONE PROTOCOL
CALL – IN CONTACT FORM

Date of site work:_____ Expected start time:_____
Name of CH2M HILL employee in the field:_____
Name of CH2M HILL employee responsible to receive contact: _____
Client Emergency Contact (if any): _____
CH2M HILL employee's contact numbers:
Radio #_____
Cell Phone #_____
Address and Location of work:_____
Directions/Map:

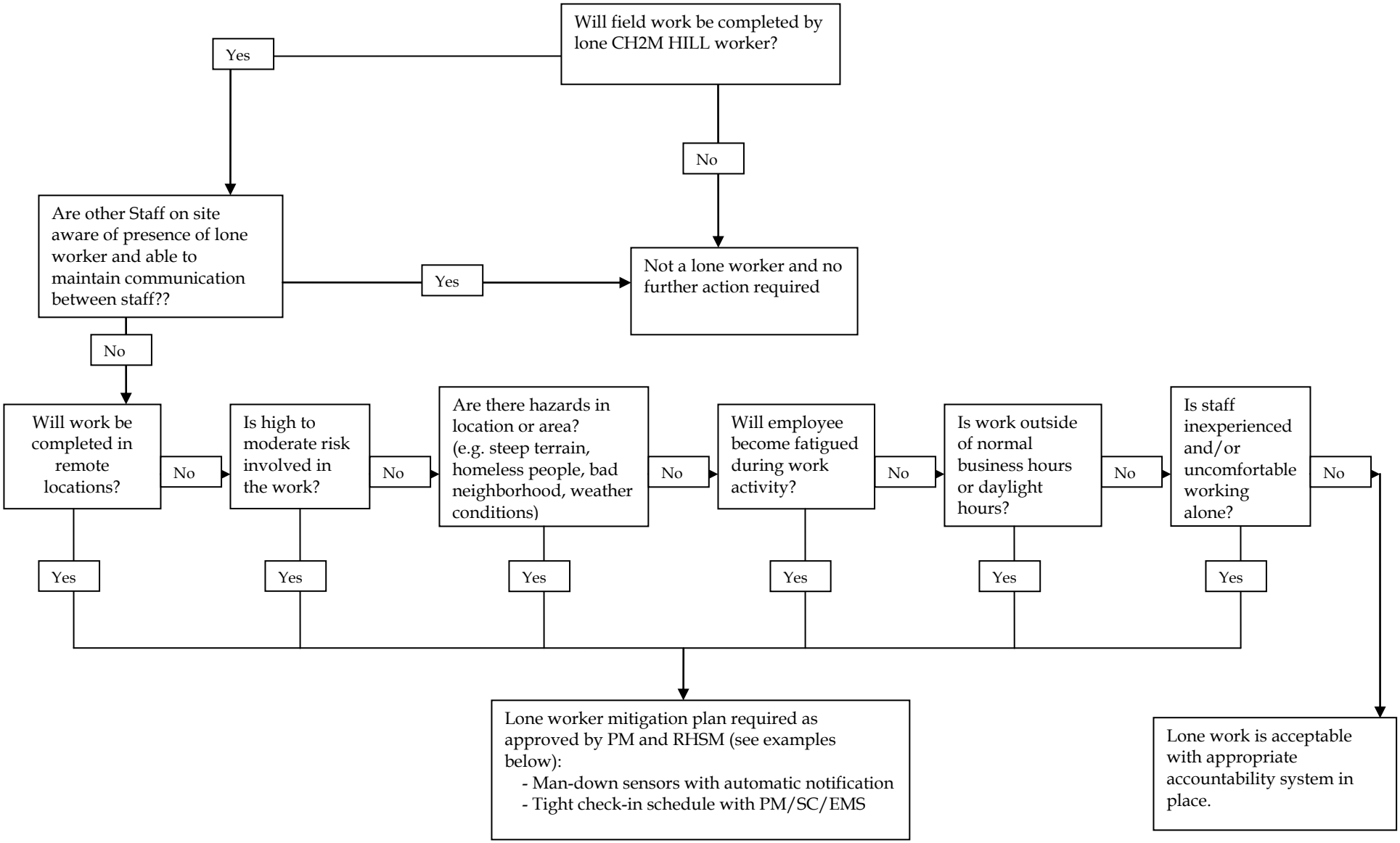
Planned Activity:_____
Specified Frequency and time for call in:_____

Time	Verified	Location

If lone worker fails to call in at specified frequency/time:

1) Call worker's radio and cell to determine if an emergency exists.
2) If no reply, immediately call Client security/emergency service if there is one at the site.
3) If there is no client security call Emergency Services (911). Inform the dispatcher there is a lone worker that cannot be contacted and there may be an emergency on site. Provide the lone worker's name, their last known location, and your contact information.
4) After Emergency Services have been contacted, call the other emergency contacts, Project Manager, and Responsible Health and Safety Manager.

Lone Worker Protocol



CH2M HILL HEALTH AND SAFETY PLAN

Attachment 7

Observed Hazard Form

CH2MHILL

OBSERVED HAZARD FORM

Name/Company of Observer (*optional*):

Date reported:_____

Time reported:_____

Contractor/s performing unsafe act or creating unsafe condition:

1. _____

2. _____

3. _____

Unsafe Act or Condition:

_____

Location of Unsafe Act or Condition:

_____

Name of CH2M HILL Representative:

_____

Corrective Actions Taken: Date: _____

_____

Project Safety Committee Evaluation: Date: _____

_____

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 8

Stop Work Order Form

CH2MHILL

Stop Work Order

REPORT PREPARED BY:

Name:	**Title:**	**Signature:**	**Date:**

ISSUE OF NONPERFORMANCE:

Description:	Date of Nonperformance:
	_____

SUBCONTRACTOR SIGNATURE OF NOTIFICATION:

Name:	**Title:**	**Signature:**	**Date:**

**** Corrective action is to be taken immediately. Note below the action taken, sign and return to CCI.* Work may not resume until authorization is granted by CH2M HILL Constructors, Inc. Representative,***

SUBCONTRACTOR'S CORRECTIVE ACTION

Description:	Date of Nonperformance:
	_____

SUBCONTRACTOR SIGNATURE OF CORRECTION

Name:	**Title:**	**Signature:**	**Date:**

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 9

Agency Inspection Target Zero Bulletin

Environmental Services Business Group

Bulletin

Subject: HSSE Agency Inspections (OSHA, EPA, DOT, State Health Department)

Do you know what YOU would do if an agency inspector arrived at your site unannounced?

Recently, a State Occupational Safety and Health Administration (OSHA) inspector made an unannounced visit to one of our Federal project sites. OSHA, U.S. Environmental Protection Agency (EPA), and authorized state or local agencies have authority to inspect any facility that is subject to health, safety, and environmental legislation. Inspections may be announced or unannounced. This particular inspector indicated that the project was targeted for an inspection because the work was funded by the American Recovery and Reinvestment Act (ARRA).

Enterprise Standard Operating Procedure (SOP) HSE-201, *Agency Inspections and Communications,* describes the responsibilities, procedures, and requirements associated with inspections conducted by external regulatory agencies, as well as the methods for communicating information to key individuals. This Target Zero Bulletin is a brief summary of what to do in the event of an agency inspection at your site. Refer to the SOP for more specific guidance.

Notification of Inspections

- If the inspection is an announced regulatory agency inspection, the Project Manager (PM) should notify the Responsible Health and Safety Manager (RHSM) and Responsible Environmental Manager (REM) well in advance of the inspection.
- If an unannounced agency inspector visits one of our projects, Field personnel must immediately notify the project Emergency Response Coordinator (ERC). Typically the ERC is the Safety Coordinator (SC).
- The ERC must immediately notify the RHSM/REM, as appropriate, of unannounced inspections, or designate someone to call the RHSM/REM. The RHSM/REMs can provide guidance to the field staff and PM.

Inspector Credential Verification

- Upon arrival, the ERC must request the inspector to provide official credentials. Record the inspector's name and office phone number or obtain the inspector's business card.
- The inspector shall sign the visitors log and be given a site-specific health, safety, and environmental protection briefing.
- The inspector shall meet any site access requirements associated with security clearances, specialized training, and medical monitoring. The CH2M HILL representative shall verify that the inspector possesses these requirements; access will only be granted to those areas where appropriate access requirements are met. Some inspectors have the authority to gain access to any work area at any time, such as an inspector with a search warrant. In these cases, we can stop work operations as necessary to protect the safety of the inspector(s).

Opening Conference

- The CH2M HILL Project Manager, ERC, RHSM, or REM, and the inspector shall determine attendees for the opening conference. The RHSM (for OSHA and other worker health and safety inspections) or REM (for environmental inspections) shall join the opening conference via conference call.
- The inspector shall inform CH2M HILL of the purpose of the inspection and provide a copy of the complaint, if applicable.
- The inspector shall outline the scope of the inspection, including employee interviews conducted in private, physical inspection of the workplace and records, possible referrals, discrimination complaints, and the closing conference(s).

Requests for OSHA Logs

- An OSHA inspector may request to review the project OSHA Injury/Illness log, better known as the OSHA 300 Log. Contact your RHSM for assistance in obtaining the OSHA 300 Log.
- Field projects with a continuous duration of one year or longer are considered to be separate establishments and are required to maintain an OSHA 300 log specific to the project. The project OSHA 300 log should be maintained onsite and kept current.
- Recordable injuries and illnesses sustained on field projects less than one year in duration are maintained on the CH2M HILL office log where the injured employee is based.

The Inspection

- The scope of the inspection shall be limited to that indicated by the inspector in the opening conference. The inspector shall be escorted to relevant areas only. The ERC or other designated by the RHSM or REM must accompany the inspector during the inspection.
- Ensure that the inspection is limited to the scope that the inspector disclosed during the opening conference. The ERC should always take notes which identify: areas inspected, machinery or equipment and materials examined, employees or other persons interviewed, and photographs taken by the inspector.
- The inspector will observe safety, health, and environmental conditions and practices and document the inspection process. The inspector may also take photos and instrument readings, examine records, collect air samples, measure noise levels, survey existing engineering controls, and monitor employee exposure to toxic vapors, gases, and dusts.
- CH2M HILL should gather duplicate information (photographs, readings, samples) in the same manner and condition as the inspector. If the equipment needed to take duplicate samples is not onsite, ask the inspector if the sampling can wait until the equipment is available. If samples are taken, request a description of the tests that the agency intends to perform on the samples and request results as soon as they are available.
- Employees may be questioned during the inspection tour. The employee can refuse to speak to an inspector, can speak to the inspector with a company representative (including management) present, or can speak to the inspector privately. It is CH2M HILL policy that employees who wish to speak to the inspector are not discriminated against, intimidated, or otherwise mistreated for exercising their rights during compliance inspections.
- Copies of documents should not be provided to the inspector without the approval of the RHSM or REM or Legal Insurance Department (LID). **DO NOT** voluntarily release documents. Respond only to inspection team requests.
- During the course of the inspection, the inspector may point out violations. For each violation, the CH2M HILL representative should ask the inspector to discuss possible corrective action. Where possible, violations detected by the inspector should be corrected immediately and noted by the inspector as corrected.
- For those items which cannot be corrected immediately, an action plan shall be formulated for timely correction. In any instance, employees exposed to hazards shall be removed from the area.

Closing Conference

After the inspection, a closing conference is normally held as follows:

- The CH2M HILL PM, ERC, RHSM or REM shall be involved via conference call in the closing conference, at a minimum;
- The inspector shall describe the apparent violations found during the inspection and other pertinent issues as deemed necessary by the inspector. CH2M HILL shall be advised of their rights to participate in any subsequent conferences, meetings or discussions. Any unusual circumstances noted during the closing conference shall be documented by the ERC;
- The inspector shall discuss violations observed during the inspection and indicate for which violations a citation and a proposed penalty may be issued or recommended;
- The ERC shall request receipts for all samples and approved documents photocopied by the inspector, request a photocopy of the inspector's photograph log, and request a copy of the final inspection report; and
- Any documentation from an agency inspection must be transmitted immediately to the RHSM or REM, and LID.

Unannounced regulatory agency inspections may happen at any time on our projects -

Get your RHSM/REM and PM involved immediately if an Inspector arrives.

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 10

Completed CH2M HILL AHAs

CH2M HILL HEALTH AND SAFETY PLAN

Attachment 11

Material Safety Data Sheets

Attachment 2
Standard Operating Procedures—CH2M HILL

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for much of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water-resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Sanford Sharpie® permanent markers.

2. On the inside cover of the log book the following information should be included:

   - Company name and address
   - Log-holders name if log book was assigned specifically to that person
   - Activity or location

- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."

4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.

5. Daily entries will be made chronologically.

6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.

7. Each page of the log book will have the date of the work and the note takers initials.

8. The final page of each day's notes will include the note-takers signature as well as the date.

9. Only information relevant to the subject project will be added to the log book.

10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.

2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified,

and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

- Description of the general sampling area – site name, buildings and streets in the area, etc.
- Station/Location identifier
- Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
- Sample matrix and type
- Sample date and time
- Sample identifier
- Draw a box around the sample ID so that it stands out in the field notes
- Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
- Number and type of sample containers collected
- Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
- Parameters to be analyzed for, if appropriate
- Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).

2. Use tables to record sampling information and field data from multiple samples.

3. Sketch sampling locations and other pertinent information.

4. Sketch well construction diagrams.

V. Attachments

Example field notes.

STANDARD OPERATING PROCEDURE

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to CH2M HILL and its subcontractors and health and safety risks to our project staff.

This SOP shall be used by Activity Managers and Project Managers to, in-turn, develop Activity-specific and project-specific utility location procedures. The activity and project-specific procedures will become part of work plans and project instructions and will be used to prepare scopes of work (SOWs) for the procurement of utility location subcontractors to meet the needs of individual projects.

This SOP also identifies the types of utility locating services that are available from subcontractors and the various tools that are used to locate utilities, and discusses when each type of service and tool may or may not be applicable.

II. Scope

Depending on the Navy/Marine Activity we typically find ourselves in one of two scenarios:

Scenario 1

The Activity provides utility locating (or dig clearance) services through the public works department or similar organization, or has a contract with an outside utility clearance service. Some of these services are provided in the form of dig permits which are required before you can dig or drill. In other cases no official permit is required and the process is somewhat vague.

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on CH2M HILL to clear the dig locations.

Table 1 provides an up to date summary of which scenarios apply to the various primary Activities served under the Navy CLEAN program.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations

using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So while the Navy's process may protect us from liability for property damage, it does not adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

Therefore, regardless of what services the Navy provides, in most cases we still need to supplement this effort with clearance services from our own third party utility location subcontractor following the procedures and guideline outlined in Section IV of this SOP. The cost implications of providing this service will range from $500 to several $1,000 depending on the size of the project.

The scope of services that we ask our subcontractors to provide can involve utility marking/mapping or the clearing of individual dig locations. In the former we ask our subs to mark all utilities within a "site" and often ask them to prepare a map based on their work. In the later, we ask them to clear (identify if there are any utilities within) a certain radius of a proposed dig/drill location.

The appropriate requested scope of services for a project will depend on the project. Clearing individual boreholes is often less expensive and allows the sub to concentrate their efforts on a limited area. However if the scope of the investigation is fluid (all borehole locations are not predetermined) it may be best to mark and map an entire site or keep the subcontractor on call.

Clearance of individual dig locations should be done to a minimum 20 foot radius around the location.

An example SOW for a utility subcontractor procurement is provided in Attachment A.

III. Services and Equipment

This section provides a general description of the services available to help us locate subsurface utilities and describes the types of equipment that these services may (or may not) use to perform their work. It identifies the capabilities of each type of equipment to help the PM specify what they should require from our utility location subs.

Services

The services that are available to us for identifying and marking underground utilities are:

- The local public/private utility-run service such as Miss Utility
- Utility location subcontractors (hired by us)

Attachment B provides a detailed description of each type of organization. It also provides contact numbers and web sites for the various Miss-Utility-type organizations in the areas where we do work for the Navy and contacts and services provided by several subcontractors that we have used or spoken to in the past.

Equipment

Attachment C provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the PM determine if the equipment being used by a subcontractor is adequate.

It is important to make the potential subcontractors aware of the possible types of utilities (and utility materials) that are at the site, and to have them explain in their bid what types of equipment they will use to locate utilities /clear dig locations, and what the limitations of these equipment are.

A list of in-house experts that can be used to help you evaluate bids or answer questions you may have is provided in Appendix C.

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by CH2M HILL and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These "dig permit" requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

Identify Activity-specific permit and/or procedural requirements for excavation and drilling activities. Contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Activity Specific: To be provided by Activity or Project Manager

CH2M HILL Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by CH2M HILL as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to CH2M HILL) to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include (these are further described in Attachment C):

- **Ground Penetrating Radar (GPR),** which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.
- **Radio Frequency (RF),** involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.

- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF
- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers,** are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. ***The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.***
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the CH2M HILL-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The CH2M HILL subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. ***This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.***
- Marking shall be done using the color coding presented in Attachment E. The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their

sidewalks and streets. ***Any particular marking requirements need to be provided in the subcontractor SOW.***

- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by CH2M HILL, when the dig location (e.g. mechanical drilling, excavating) is expected to be within 5 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

A- Example SOW for Utility Location Subcontractor Procurement
B - Services Available for Identifying and Marking Underground Utilities
C – Equipment Used for Identifying Underground Utilities
D – Utility Clearance Documentation Form
E – Utility Marking Color Codes

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-XXX

Scope of Work

Subsurface Utility Locating

Site XX

Navy Activity

City, State

A licensed and insured utility locator will be subcontracted to identify and mark out subsurface utilities for an environmental investigation/remediation project at Site XX of <<insert name of base, city, and state>>. The subcontractor will need to be available beginning at <<insert time>> on <<insert date>>. It is estimated that the work can be completed within XX days.

Proposed Scope of Work

The subcontractor will identify and mark all subsurface utilities (CHOOSE 1) that lie within a radius of 20 feet of each of XX sampling locations at Site XX shown on the attached Figure 1; (OR) that lie within the bounds of Site XX as delineated on the attached Figure 1. (If multiple sites are to be cleared, provide maps of each site with sample locations or clearance boundaries clearly delineated and a scale provided.)

Utilities will be identified using all reasonably available as-built drawings, electronic locating devices, and any other means necessary to maintain the safety of drilling and sampling personnel and the protection of the base infrastructure. The location of utilities identified from as-built drawings or other maps must be verified in the field prior to marking.

Base utility drawings for the Site(s) (CHOOSE 1) can be found at <<insert specific department and address or phone number on the base>> and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by CH2M HILL upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

Field verification will include detection using nonintrusive subsurface detection equipment (magnetometers, GPR, etc) as well as opening manhole covers to verify pipe

directions. As part of the bid, the Subcontractor shall provide a list of the various subsurface investigation tools they propose to have available and use at the site and what the limitations are of each tool.

A CH2M HILL representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1)** ***a 20-ft radius of the XX proposed soil boring locations*** **(OR)** ***within the boundary of the site(s)*** as identified on the attached figure(s) will be marked using **paint** ***(some Bases such as the WNY may have restrictions on the use of permanent paint)*** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the ***Buried Utility Location Tracking Form*** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to CH2M HILL (field staff or project manager) within 24 hours of completing the utility locating activities.

(OPTIONAL) ***The subcontractor shall also provide a map (or hand sketch) of the identified utilities to the Engineer within XX days of field demobilization. The map shall include coordinates or ties from fixed surface features to each identified subsurface utility.***

Bid Sheet/Payment Units

The subcontractor will bid on a time and materials basis for time spent on site and researching utility maps. Mobilization (including daily travel to the site) should be bid as a lump sum, as well as the preparation of the AHA and any required mapping. The per diem line item should be used if the field crew will require overnight accommodations at the project site.

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of CH2M HILL.

The subcontractor shall also prepare and provide to the Engineer, at least 48 hours prior to mobilization, an acceptable Activity Hazard Analysis (AHA) using the attached AHA form or similar.

It is also required that all subcontractor personnel who will be on site attend the daily 15-minute health and safety tailgate meeting at the start of each day in the field.

Subcontractor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employers will be notified.

Subcontractor personnel under the influence of prescription or over-the-counter medication that may impair their ability to operate equipment will not be permitted to do so. It is expected that the subcontractor will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

Security

The work will be performed on US Navy property. CH2M HILL will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to CH2M HILL, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

- Name
- Birth Place
- Birth Date
- Social Security Number
- Drivers License State and Number
- Citizenship

Please be advised that no weapons, alcohol, or drugs will be permitted on the Navy facility at any time. If any such items are found, they will be confiscated, and the Subcontractor will be dismissed.

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of <<state>> and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer's recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the CH2M HILL Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor's personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the CH2M HILL representative to resume operations. Subcontractor standby time also will include potential delays caused by the CH2M HILL representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

Cumulative Subcontractor standby will be accrued in increments no shorter than 15 minutes (i.e., an individual standby episode of less than 15 minutes is not chargeable).

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and CH2M HILL representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on CH2M HILL's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and CH2M Hill representative's daily logs. No payment will be made for down time.

Schedule

It is anticipated that the subsurface utility locating activities will occur on <<insert date>>. It is estimated that the above scope will be completed within XXX days.

Attachment B - Services Available for Identifying and Marking Underground Utilities

The services that are available to us for identifying and marking underground utilities are:

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility
- Utility location subcontractors (hired by CH2M HILL)

Each are discussed below.

Navy Public Works Department

A Public Works Department (PWD) is usually present at each Activity. The PWD is responsible for maintaining the public works at the base including management of utilities. In many cases, the PWD has a written permit process in place to identify and mark-out the locations of Navy-owned utilities [Note: The PWD is usually NOT responsible for the locations/mark-outs of non-Navy owned, public utilities (e.g., Washington Gas, Virginia Power, municipal water and sewer, etc.). Therefore, it is likely that we will have to contact other organizations besides the PWD in order to identify non-Navy owned, public utilities].

At some Activities, there may not be a PWD, the PWD may not have a written permit process in place, or the PWD may not take responsibility for utility locating and mark-outs. In these cases, the PWD should still be contacted since it is likely that they will have the best understanding of the utility locations at the Activity (i.e., engineering drawings, institutional knowledge, etc.). Subsequently, the PWD should be brought into a cooperative arrangement (if possible) with the other services employed in utility locating and mark-out in order to have the most comprehensive assessment performed.

At all Activities we should have a contact (name and phone number), and preferably an established relationship, with PWD, either directly or through the NAVFAC Atlantic, Midlant, or Washington NTR or Activity Environmental Office that we can work with and contact in the event of problems.

Miss Utility or "One Call" Services for Public Utility Mark-outs

Miss Utility or "One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Ms. Utilities and is part of the response process for Miss

Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs to be performed. The "One Call" services are free to the public. Note that the "One Call" centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the "One Call" center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility "One Call" center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

A national listing of the "One Call" service centers for each state is presented on the web at http://www.underspace.com/refs/ocdir.htm. For the Mid-Atlantic region, the following "One Call" service centers are available.

Name	Phone	Website	Comments
Miss Utility of DELMARVA	800-257-7777	www.missutility.net	Public utility mark-outs in Delaware, Maryland, Washington, DC, and Northern Virginia
Miss Utility of Southern Virginia (One Call)	800-552-7001	not available	Public utility mark-outs in Southern Virginia
Miss Utility of Virginia	800-257-7777 800-552-7007	www.missutilityofvirginia.com	General information on public utility mark-outs in Virginia, with links to Miss Utility of DELMARVA and Miss Utility of Southern Virginia (One Call)
Miss Utility of West Virginia, Inc	800-245-4848	none	Call to determine what utilities they work with in West Virginia
North Carolina One Call Center	800-632-4949	www.ncocc.org/ncocc/default.htm	Public Utility Markouts in North Carolina

Private Subcontractors

1. Utility-locating support is required at some level for most all CH2M HILL field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort, including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

   The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and

recent construction is limited, CH2M HILL may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult, CH2M HILL will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately $200 per day for a simple EM effort (usually one crew member and one instrument) to approximately $1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

The following table provides a list of recommended geophysical surveying support subcontractors that can be used for utility-locating services:

Company Name and Address	Contact Name and Phone Number	Equipment[1]					Other Services[2]		
		1	2	3	4	5	A	B	C
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			✓					
Utilities Search, Inc.*	Jim Davis 703-369-5758	✓				✓	✓	✓	✓
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	✓					✓	✓	✓
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	✓	✓						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	✓	✓	✓	✓	✓	✓	✓	✓
Earth Resources Technology. Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	✓	✓	✓	✓	✓	✓	✓	
Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	✓	✓	✓	✓	✓	✓	✓	✓

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that CH2M HILL requests for this type of work at many Navy sites.

[1]Equipment types are:

1. Simple electromagnetic instruments, usually hand-held
2. Other, more innovative, electromagnetic instruments, including larger instruments for more area coverage
3. Ground-penetrating radar systems of all kinds
4. Audio-frequency detectors of all kinds
5. Radio-frequency detectors of all kinds

[2]Other services include:

A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.

B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.

C. Concrete/asphalt coring and pavement/surface restoration.

Attachment C – Equipment Used for Identifying Underground Utilities

This attachment provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the AM and PM determine if the equipment being proposed by a subcontractor or Navy is adequate. A list of in-house experts that can be used to answer questions you may have is provided below.

CH2M HILL In-house Utility Location Experts

Tamir Klaff/WDC

Home Office Phone – 703-669-9611

Electromagnetic Induction (EMI) Methods

EMI instruments, in general, induce an electromagnetic field into the ground (the primary field) and then record the response (the secondary field), if any. Lateral changes in subsurface conductivity, such as caused by the presence of buried metal or by significant soil variations, cause changes in the secondary field recorded by the instrument and thus enable detection and mapping of the subsurface features. It should be noted that EMI only works for electrically conductive materials--plastic or PVC pipes are generally not detected with EMI. Water and gas lines are commonly plastic, although most new lines include a copper "locator" strip on the top of the PVC to allow for detection with EMI.

EMI technology encompasses a wide range of instruments, each with inherent strengths and weaknesses for particular applications. One major division of EMI is between "time-domain" and "frequency-domain" instruments that differ in the aspect of the secondary field they detect. Another difference in EMI instruments is the operating frequency they use to transmit the primary field. Audio- and radio-frequencies are often used for utility detection, although other frequencies are also used. Consideration of the type of utility expected, surface features that could interfere with detection, and the "congestion" of utilities in an area, should be made when choosing a particular EMI instrument for a particular site.

One common EMI tool used for utility location is a handheld unit that can be used to quickly scan an area for utilities and allows for marking locations in "real time". This method is most commonly used by "dig-safe" contractors marking out known utilities prior to excavation. It should be noted that this method works best when a signal (the primary field) can be placed directly onto the line (i.e., by clamping or otherwise connecting to the end of the line visible at the surface, or for larger utilities such as sewers, by running a transmitter through the utility). These types of tools also have a limited capability to scan an area for unknown utilities. Usually this requires having enough area to separate a hand held transmitter at least a hundred feet from the

receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

In addition to the handheld EMI units, larger, more powerful EMI tools are available that provide more comprehensive detection and mapping of subsurface features. Generally, data with these methods are collected on a regular grid in the investigation area, and are then analyzed to locate linear anomalies that can be interpreted as utilities. These methods will usually detect *all* subsurface metal (above a minimum size), including pieces of abandoned utilities. In addition, in some situations, backfill can be detected against native soils giving information on trenching and possible utility location. Drawbacks to these methods are that the secondary signals from utilities are often swamped (i.e., undetectable) close to buildings and other cultural features, and that the subsurface at heavily built-up sites may be too complicated to confidently interpret completely.

Hand-held metal detectors (treasure-finders) are usually based on EMI technology. They can be used to locate shallow buried metal associated with utilities (e.g., junctions, manholes, metallic locators). Advantages of these tools is the ease of use and real-time marking of anomalies. Drawbacks include limited depths of investigations and no data storage capacity.

Ground Penetrating Radar (GPR)

GPR systems transmit radio and microwave frequency (e.g., 80 megaHertz to 1,000 megaHertz) waves into the ground and then record reflections of those waves coming back to the surface. Reflections of the radar waves typically occur at lithologic changes, subsurface discontinuities, and subsurface structures. Plastic and PVC pipes can sometimes be detected in GPR data, especially if they are shallow, large, and full of a contrasting material such as air in a wet soil, or water in a dry soil. GPR data are usually collected in regular patterns over an area and then analyzed for linear anomalies that can be interpreted as utilities. GPR is usually very accurate in x-y location of utilities, and can be calibrated at a site to give very accurate depth information as well. A significant drawback to GPR is that depth of investigation is highly dependant on background soil conductivity, and it will not work on all sites. It is not uncommon to get only 1-2 feet of penetration with the signal in damp, clayey environments. Another drawback to GPR is that sites containing significant fill material (e.g., concrete rubble, scrap metal, garbage) will result in complicated anomalies that are difficult or impossible to interpret.

Magnetic Field Methods

Magnetic field methods rely on detecting changes to the earth's magnetic field caused by ferrous metal objects. This method is usually more sensitive to magnetic metal (i.e., deeper detection) than EMI methods. A drawback to this method is it is more susceptible to being swamped by surface features such as fences and cars. In addition, procedures must usually be implemented that account for natural variations in the earth's background field as it changes throughout the day. One common use of the method is to measure and analyze the gradient of the magnetic field, which eliminates most of the drawbacks to the method. It should be noted this method only detects

ferrous metal, primarily iron and steel for utility location applications. Some utility detector combine magnetic and EMI methods into a single hand-held unit.

Optical Methods

Down the hole cameras may be useful in visually reviewing a pipe for empty conduits and/or vaults.

Attachment D – Utility Clearance Documentation Form

Attachment E – Utility Marking Color Codes

The following is the standard color code used by industry to mark various types of utilities and other features at a construction site.

White – Proposed excavations and borings

Pink – Temporary survey markings

Red – Electrical power lines, cables, conduits and lighting cables

Yellow – Gas, oil, steam, petroleum or gaseous materials

Orange – Communication, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

STANDARD OPERATING PROCEDURE

Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Water Quality Parameter Meter with Flow-through Cell

I. Purpose and Scope

The purpose of this procedure is to provide a general guideline for using a water quality parameter meter (e.g., Horiba® U-22 or YSI) for field measurements of pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature of aqueous samples. The YSI instrument does not measure turbidity. A separate turbidity meter (i.e., Hanna Turbidity Meter) will need to be used in conjunction with the YSI meter. The operator's manual should be consulted for detailed operating procedures.

II. Equipment and Materials

- Water Quality Parameter Meter such as a Horiba® U-22 Water Quality Monitoring System or YSI with flow-though cell
- Auto-Calibration Standard Solution (provided by rental company)
- Distilled water in squirt bottle

III. Procedures and Guidelines

A. Parameters and Specifications:

Parameter	Range of measurement	Accuracy
pH	0 to 14 pH units	+/- 0.1 pH units
Specific conductance	0 to 9.99 S/m	+/- 3 % full scale
Turbidity	0 to 800 NTU	+/- 5 % full scale
Dissolved oxygen	0 to 19.99 mg/l	+/- 0.2 mg/l A
Temperature	0 to 55 ^{o}C	+/- 1.0 ^{o}C
ORP	-999 to +999 mV	+/- 15 mV
Salinity	0 to 4 %	+/- 0.3 %

B. Calibration:

Prior to each day's use, clean the probe and flow-through cell using deionized water and calibrate using the Standard Solution.

Horiba U22 Calibration procedure:

1. Fill a calibration beaker with standard solution to the recommended fill line.
2. Insert the probe into the beaker. All the parameter sensors will now be immersed in the standard solution except the D.O. sensor; the D.O. calibration is done using atmospheric air.
3. Turn power on and allow some time for the machine to warm-up prior to starting the calibration. When the initial readings appear to stabilize the instrument is ready to calibrate.
4. Press CAL key to put the unit in the calibration mode.
5. Press the ENT key to start automatic calibration. Wait a moment, and the upper cursor will gradually move across the four auto-calibration parameters one by one: pH, COND, TURB, and DO. When the calibration is complete, the readout will briefly show END. The instrument is now calibrated.
6. If the unit is calibrated properly the instrument readings, while immersed in the standard solution, will match the standard solution values provided on the solution container. The typical standard solution values are: pH = 4.0 +/- 3%, conductivity 4.49 mS/cm +/- 3%, and turbidity = 0 NTU +/- 3%.
7. Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

YSI Calibration procedure:

1. Press the **On/off** key to display the run screen
2. Press the **Escape** key to display the main menu screen
3. Use the arrow keys to highlight the **Calibrate**
4. Press the **Enter** key. The Calibrate screen is displayed
5. Choose the parameter to calibrate

A. Conductivity Calibration:

This procedure calibrates specific conductance (recommended), conductivity and salinity. Calibrating any one option automatically calibrates the other two.

1) Use the arrow keys to highlight the **Conductivity** selection
2) Press **Enter.** The Conductivity Calibration Selection Screen is displayed.
3) Use the arrow keys to highlight the Specific Conductance selection.
4) Press **Enter.** The Conductivity Calibration Entry Screen is displayed.

5) Place the correct amount of conductivity standard (see Instrument Manual) into a clean, dry or pre-rinsed transport/calibration cup.
6) Carefully immerse the sensor end of the probe module into the solution.
7) Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.

   NOTE: The sensor must be completely immersed past its vent hole. Using the recommended volumes from the Instrument Manual Calibration Volumes should ensure that the vent hole is covered.
8) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not over tighten as this could cause damage to the threaded portions.
9) Use the keypad to enter the calibration value of the standard you are using.

   NOTE: Be sure to enter the value in **mS/cm at 25□C**.
10) Press **Enter**. The Conductivity Calibration Screen is displayed.
11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the reading under Specific Conductance. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the Conductivity Calibrate Selection Screen
14) Press **Escape** to return to the calibrate menu.
15) Rinse the probe module and sensors in tap or purified water and dry.

B. Dissolved Oxygen Calibration:

This procedure calibrates dissolved oxygen. Calibrating any one option (% or mg/L) automatically calibrates the other.

1) Go to the calibrate screen as described in Section

   NOTE: The instrument must be on for at least 20 minutes to polarize the DO sensor before calibrating.
2) Use the arrow keys to highlight the **Dissolved Oxygen** selection.
3) Press **Enter**. The dissolved oxygen calibration screen is displayed.
4) DO calibration in mg/L is carried out in a water sample which has a known concentration of dissolved oxygen (usually determined by a Winkler titration).
5) Use the arrow keys to highlight the **DO mg/L** selection.
6) Press **Enter**. The DO mg/L Entry Screen is displayed.
7) Place the probe module in water with a known DO concentration.

   NOTE: Be sure to completely immerse all the sensors.
8) Use the keypad to enter the known DO concentration of the water.
9) Press **Enter**. The Dissolved Oxygen mg/L Calibration Screen is displayed.
10) Stir the water with a stir bar, or by rapidly moving the probe module, to provide fresh sample to the DO sensor.

11) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
12) Observe the DO mg/L reading, when the reading is stable (shows no significant change for approximately 30 seconds), press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
13) Press **Enter**. This returns you to the DO calibration screen.
14) Press **Escape** to return to the calibrate menu.
15) Rinse the probe module and sensors in tap or purified water and dry.

C. pH Calibration:

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **pH** selection.
3) Press **Enter**. The pH calibration screen is displayed.
    - Select the **1-point** option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a one point calibration. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select only one pH buffer.
    - Select the **2-point** option to calibrate the pH sensor using only two calibration standards. Use this option if the media being monitored is known to be either basic or acidic. For example, if the pH of a pond is known to vary between 5.5 and 7, a two-point calibration with pH 7 and pH 4 buffers is sufficient. A three point calibration with an additional pH 10 buffer will not increase the accuracy of this measurement since the pH is not within this higher range.
    - Select the **3-point** option to calibrate the pH sensor using three calibration solutions. In this procedure, the pH sensor is calibrated with a pH 7 buffer and two additional buffers. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated. The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to select a third pH buffer.
4) Use the arrow keys to highlight the **2-point** selection.
5) Press **Enter**. The pH Entry Screen is displayed.
6) Place the correct amount of pH buffer into a clean, dry or pre-rinsed transport/calibration cup.

    NOTE: For maximum accuracy, the pH buffers you choose should be within the same pH range as the water you are preparing to sample.
    NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the pH sensor with a small amount of buffer that can be discarded. Be certain that you avoid cross-contamination of buffers with other solutions.
7) Carefully immerse the sensor end of the probe module into the solution.

8) Gently rotate and/or move the probe module up and down to remove any bubbles from the pH sensor.

   NOTE: The sensor must be completely immersed. Using the recommended volumes from Table 6.1 Calibration Volumes, should ensure that the sensor is covered.

9) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.

   NOTE: Do not over tighten as this could cause damage to the threaded portions.

10) Use the keypad to enter the calibration value of the buffer you are using **at the current temperature**.

    NOTE: pH vs. temperature values are printed on the labels of all YSI pH buffers.

11) Press **Enter**. The pH calibration screen is displayed.
12) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
13) Observe the reading under pH, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
14) Press **Enter**. This returns you to the Specified pH Calibration Screen.
15) Rinse the probe module, transport/calibration cup and sensors in tap or purified water and dry.
16) Repeat steps 6 through 13 above using a second pH buffer.
17) Press **Enter**. This returns you to the pH Calibration Screen.
18) Press **Escape** to return to the calibrate menu.
19) Rinse the probe module and sensors in tap or purified water and dry.

D. ORP Calibration:

1) Go to the calibrate screen.
2) Use the arrow keys to highlight the **ORP** selection.
3) Press **Enter**. The ORP calibration screen is displayed.
4) Place the correct amount of a known ORP solution into a clean, dry or pre-rinsed transport/calibration cup.

   NOTE: Before proceeding, ensure that the sensor is as dry as possible. Ideally, rinse the ORP sensor with a small amount of solution that can be discarded. Be certain that you avoid cross-contamination with other solutions.

5) Carefully immerse the sensor end of the probe module into the solution.
6) Gently rotate and/or move the probe module up and down to remove any bubbles from the ORP sensor.

   NOTE: The sensor must be completely immersed.

7) Screw the transport/calibration cup on the threaded end of the probe module and securely tighten.
8) Use the keypad to enter the correct value of the calibration solution you are using at the current temperature.

9) Press **Enter**. The ORP calibration screen is displayed.
10) Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
11) Observe the reading under ORP, when the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to Continue.
12) Press **Enter**. This returns you to the Calibrate Screen.
13) Rinse the probe module and sensors in tap or purified water and dry. Record the calibration data (e.g. time, instrument ID, solution lot number and expiration date, final calibrated readings, and solution temperature in the field logbook.

C. Sample Measurement:

Horiba U22 measurement procedure:

As water passes through the flow-through the flow cell, press MEAS to obtain reading; record data in a field notebook.

YSI measurement procedure:

As water passes through the flow-through the flow cell, the readings are displayed for each parameter. Record the water quality parameter data in a field notebook. In addition, the data is recorded in the YSI and can be downloaded to a computer following completion of the sampling event.

IV. Key Checks and Preventive Maintenance

- Calibrate meter
- Clean probe with deionized water when done
- Refer to operations manual for recommended maintenance and troubleshooting
- Check batteries, and have a replacement set on hand
- Due to the importance of obtaining these parameters, the field team should have a spare unit readily available in case of an equipment malfunction.

V. References

YSI 556 Multi Probe System Operator Manual

STANDARD OPERATING PROCEDURE

Low-Flow Groundwater Sampling from Monitoring Wells

I. Purpose and Scope

This SOP presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Horiba® U-22 or equivalent water quality meters to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- Generator or alternate power source depending on pump type
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing for metals and other inorganics
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Sample containers
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screen interval(s), and the method for disposal of purged water.

2. Calibrate instruments according to manufacturer's instructions.

3. The well number, site, date, and condition are recorded in the field logbook.

4. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed. To avoid cross-contamination, do not let any downhole equipment touch the ground.

5. All sampling equipment and any other equipment to be placed in the well is cleaned and decontaminated before sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

6. Water level measurements are collected in accordance with the *Water Level Measurements* SOP. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well construction log.

7. Attach and secure the tubing to the low-flow pump. Lower the pump slowly into the well and set it at approximately the middle of the screen. Place the pump intake in the middle of the saturated screen length and should be at least two feet above the bottom of the well to avoid mobilization of any sediment present in the bottom.

8. Insert the measurement probes into the flow-through cell. The purged groundwater is directed through the cell, allowing measurements to be collected before the water contacts the atmosphere.

9. If using a generator, locate it 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.

10. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5-liter to 1 liter per minute. The initial field parameters of pH, specific conductance, dissolved oxygen, ORP, turbidity, and temperature of water are measured and recorded in the field logbook.

11. The water level should be monitored during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.3-foot). The water level should stabilize for the specific purge rate. There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1- to 0.2-liter per minute) to avoid affecting well drawdown.

12. During purging, the field parameters are measured frequently (every 5 minutes) until the parameters have stabilized. Field parameters are considered stable when measurements meet the following criteria:

    - pH: within 0.1 pH units
    - Specific conductance: within 3 percent

- Dissolved oxygen: within 10 percent
- Turbidity: within 10 percent for values greater than 5 NTU; if 3 turbidity values are less than 5 NTU, consider the values as stabilized
- ORP: within 10 mV
- Temperature: within 3 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The elapsed time between completion of purging and collection of the groundwater sample should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

VOC samples are normally collected first and directly into pre-preserved sample containers.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that ¼ or 3/8 inch inside diameter tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, collect non-VOC dissolved gasses samples first, then increase flow rate slightly until water completely fills the tubing and collect the VOC/dissolved gases samples. Record new flow rate and drawdown depth.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing,, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container. If a bailer is used, filtration may be driven by a peristaltic pump.
4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus.

5. The bottle is capped and clearly labeled.

6. Samples are placed in appropriate containers and, if necessary, packed with ice in coolers as soon as practical.

7. Nondedicated equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)

2. Sample source and source description

3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements

4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

5. Additional remarks

C. Additional remarks

1. If the well goes dry during purging, wait until it recovers sufficiently to remove the required volumes to sample all parameters. It may be necessary to return periodically to the well but a particular sample (e.g., large amber bottles for semivolatile analysis) should be filled at one time rather than over the course of two or more visits to the well.

2. Disposable tubing is disposed of with PPE and other site trash.

IV. Attachments

White paper on reasons and rationale for low-flow sampling.

V. Key Checks and Preventative Maintenance

- The drawdown in the well should be minimized as much as possible (preferably no more than 0.5-foot to 1 foot) so that natural groundwater-flow conditions are maintained as closely as possible.

- The highest purging rate should not exceed 1 liter per minute. This is to keep the drawdown minimized.

- Stirring up of sediment in the well should be avoided so that turbidity containing adsorbed chemicals is not suspended in the well and taken in by the pump.

- Overheating of the pump should be avoided to minimize the potential for losing VOCs through volatilization.
- Keep the working space clean with plastic sheeting and good housekeeping.
- Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:
    - Inspect sampling pump regularly and replace as warranted
    - Inspect quick-connects regularly and replace as warranted
    - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Attachment to the SOP on Low-Flow Sampling Groundwater Sampling from Monitoring Wells

White Paper on Low-Flow Sampling

EPA recommends low-flow sampling as a means of collecting groundwater samples in a way that minimizes the disturbance to the natural groundwater flow system and minimizes the introduction of contamination into the samples from extraneous sources. The following are details about these issues.

When a pump removes groundwater from the well at the same rate that groundwater enters the well through the screen, the natural groundwater-flow system around the well experiences a minimum of disturbance. Some disturbance is bound to occur because you are causing groundwater to flow to the well in a radial fashion that otherwise would have flowed past it. However, the resulting low-flow sample provides the most-representative indication we can get of groundwater quality in the immediate vicinity of the well.

Normally, when a well is pumped at an excessive rate that drops the water level in the well below the water level in the aquifer, the water cascades down the inside of the well screen when it enters the well. The turbulence from this cascading causes gases such as oxygen and carbon dioxide to mix with the water in concentrations that are not representative of the native groundwater and are higher than expected. This causes geochemical changes in the nature of the water that can change the concentrations of some analytes, particularly metals, in the groundwater sample, not mention its effect on the dissolved oxygen levels that then will be measured in the flow-through cell. Such turbulence also may cause lower-than-expected concentrations of volatile organic compounds due to volatilization.

For wells in which the water level is above the top of the screen, the water up in the riser is out of the natural circulation of the groundwater and, therefore, can become stagnant. This stagnant water is no longer representative of natural groundwater quality because its pH, dissolved-oxygen content, and other geochemical characteristics change as it contacts the air in the riser. If we minimize the drawdown in the well when we pump, then we minimize the amount of this stagnant water that is brought down into the well screen and potentially into the pump. As a result, a more-representative sample is obtained.

Typically, wells contain some sediment in the bottom of the well, either as a residue from development that has settled out of the water column or that has sifted through the sand pack and screen since the well was installed. This sediment commonly has adsorbed on it such analytes as metals, SVOCs, and dioxins that normally would not be dissolved in the groundwater. If these sediments are picked up in the groundwater when the well is disturbed by excessive pumping, they can:

- Make filtering the samples for metals analysis more difficult
- Add unreasonably to the measured concentration of SVOCs and other organic compounds

The SOP for low-flow sampling has been modified recently and should be consulted for additional information about low-flow sampling and ways of dealing with wells in which the water level cannot be maintained at a constant level.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® (or Alconox®) and water solution
- Concentrated (V/V) pesticide grade methanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% methanol solution pumped through the pump. (DO NOT USE ACETONE).

6. Rinse with 1 gallon of tap water.

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and methanol solution (DO NOT USE ACETONE).
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, methanol, and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Methanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM–Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam-cleaning area will be designed to contain decontamination wastes and waste waters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. Field Analytical Equipment

1. Water Level Indicators

   Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

   a. Rinse with tap water
   b. Rinse with de-ionized water
   c. Solvent rinse with methanol
   d. Rinse with de-ionized water

2. Probes

   Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, OVM equipment, the probe will be wiped with clean paper-towels or cloth wetted with methanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- The effectiveness of field cleaning procedures may be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis.

STANDARD OPERATING PROCEDURE

Disposal of Waste Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced. Also, the site investigation-derived waste management plan should be consulted for additional information and should take precedence over this SOP.

II. Equipment and Materials

A. Fluids

- DOT-approved 55-gallon steel drums or Baker® Tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Paint Pens
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- DOT-approved 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Paint Pens
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or rolloffs or Baker® Tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will

be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. The drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums containing the same media. Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished by collecting a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. The analysis will be used to determine if drilling wastes are covered by land disposal restrictions.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individuals wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- Generator Contact Information
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C if the results indicate hazardous waste or labeled as non-hazardous if applicable.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to Baker® Tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the drum storage area by the drilling services subcontractor. Drums should be stored on pallets on plastic sheeting with a short berm wall (hay bales or 2 x 4 planks or equivalent) to capture small spills.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. However, prior to disposal to the sanitary sewer system, approval and contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of through contract with a commercial transport and disposal firm.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Check that representative samples of the containerized materials are obtained.
- Be sure that all state and federal regulations are considered when classifying waste for disposal.

STANDARD OPERATING PROCEDURE

Equipment Blank and Field Blank Preparation

I. Purpose

To prepare blanks to determine whether decontamination procedures are adequate and whether any cross-contamination is occurring during sampling due to contaminated air and dust.

II. Scope

The general protocols for preparing the blanks are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II or lab grade water)
- Millipore™ deionized water
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment.*

B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notebook as well as the type and lot number of the water used.

For non-volatiles analyses, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a Grundfos Redi-Flo2 pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.

D. To collect a field blank, slowly pour ASTM Type II or lab grade water directly into sample containers.

E. Document and ship samples in accordance with the procedures for other samples.

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II or lab grade water.

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- “This Side Up” labels
- “Fragile” labels
- Vermiculite
- Ziplock bags or bubble wrap
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of vermiculite or absorbent pads.

B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.

C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.

D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.

G. Fill remaining spaces with vermiculite or absorbent pads.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with tape to avoid seals being able to be peeled from the cooler.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate vermiculite or other packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

The purpose of this SOP is to provide information on chain-of-custody procedures to be used under the CLEAN Program.

II Scope

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region specific or site-specific requirements for chain-of-custody.

III Definitions

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

IV Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is responsible for ensuring that chain-of-custody procedures are implemented. The Project Manager also is responsible for determining that custody procedures have been met by the analytical laboratory.

Field Team Leader - The Field Team Leader is responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sample Personnel - It is the responsibility of the field sampling personnel to initiate chain-of-custody procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

V Procedures

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

V.1 Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When *in situ* measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s),
- Contract Task Order (CTO) Number,
- Project Sample Number,
- Sample location or sampling station number,
- Date and time of sample collection and/or measurement,

- Field observations,
- Equipment used to collect samples and measurements, and
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

V.1.1 Sample Label

Samples, other than for *in situ* measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project - CTO Number.
- Station Location - The unique sample number identifying this sample.
- Date - A six-digit number indicating the day, month, and year of sample collection (e.g., 01/21/08).
- Time - A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 a.m., and 1629 is 4:29 p.m.).
- Medium - Water, soil, sediment, sludge, waste, etc.
- Sample Type - Grab or composite.
- Preservation - Type and quantity of preservation added.
- Analysis - VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By - Printed name of the sampler.
- Remarks - Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site). The field team should always follow the sample ID system prepared by the project EIS and reviewed by the Project Manager.

V.2 Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed of.

V.2.1 Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- A Chain-of-Custody Record will be prepared for each individual cooler shipped and will include ***only*** the samples contained within that particular cooler. The Chain-of-Custody Record for that cooler will then be sealed in a zip-log bag and placed in the cooler prior to sealing. This ensures that the laboratory properly attributes trip blanks with the correct cooler and allows for easier tracking should a cooler become lost during transit.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once downloaded to the server or developed, the electronic files or photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographic prints will be stored in the project files. To identify sample locations in photographs, an easily read sign with the appropriate sample/ location number should be included.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions (e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.)

V.2.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. **A Chain-of-Custody Record Form must be completed for each cooler and should include only the samples contained within that cooler**. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below:

- Enter header information (CTO number, samplers, and project name).

- Enter sample specific information (sample number, media, sample analysis required and analytical method grab or composite, number and type of sample containers, and date/time sample was collected).

- Sign, date, and enter the time under "Relinquished by" entry.

- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample-shipping package. Retain the copy with field records.

- Sign and date the custody seal, a 1-inch by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.

- Place the seal across the shipping container opening (front and back) so that it would be broken if the container were to be opened.

- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

VI Quality Assurance Records

Once samples have been packaged and shipped, the Chain-of-Custody copy and airbill receipt become part of the quality assurance record.

VII Attachments

A. Sample Label
B. Chain of Custody Form
C. Custody Seal

VIII References

USEPA. *User's Guide to the Contract Laboratory Program*. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

STANDARD OPERATING PROCEDURE

Multi RAE Photoionization Detector (PID)

I. Purpose

The purpose of this SOP is to provide general reference information for using the Multi RAE PID in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

II. Scope

This procedure provides information on the field operation and general maintenance of the Multi RAE PID. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

III. Definitions

Carbon Monoxide Sensor (CO) - Expresses the Carbon Monoxide concentration in ppm.

Volatile Organic Compound (VOC) – Expresses the VOC concentration in ppm

Lower Explosive Limit (LEL) - Combustible gas is expressed as a percent of the lower explosive limit.

Hydrogen Sulfide Sensor (H_2S) - Expresses the Hydrogen Sulfide concentration in ppm.

Oxygen Sensor (OXY) - Expresses the Oxygen concentration as a percentage.

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

IV. Responsibilities

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Health and Safety Coordinator - The Health and Safety Coordinator is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the field team performing air

monitoring activities have been briefed and trained to execute these procedures before the start of site operations.

Safety Coordinator-Hazard Worker (SC-HW)- The SC-HW is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the field personnel. The SC-HW will coordinate these activities with the Field Team Leader if the SC-HW is not the Field Team Leader as well.

Field team - It is the responsibility of the field team to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/ Safety Coordinator-Hazard Worker. The field personnel are responsible for documenting all air monitoring results in the field logbook during each field investigation.

V. Procedures

The Multi RAE utilizes the principle of detecting sensors. The PID operates on the principle that most organic compounds and some inorganic compounds are ionized when they are bombarded by high-energy ultraviolet light. These compounds absorb the energy of the light, which excites the molecules and results in a loss of electron and the formation of a positively charged ion. The number of ions formed and the ion current produced is directly proportional to mass and concentration. The amount of energy required to displace an electron is called ionization potential (IP). The air sample is drawn into a UV lamp using a pump or a fan. The energy of the lamp determines whether a particular chemical will be ionized. Each chemical compound has a unique ionizing potential. When the UV light energy is greater than the ionization potential of the chemical, ionization will occur. When the sample is ionized, the electrical signal is displayed on an analog or digital output. Although the output does not distinguish between chemicals, it does detect an increase in the ion current. If only one chemical is present in the air, it is possible to use PIDs quantitatively. Chemical structure and lamp intensity affects the sensitivity of the instrument to a given contaminant. All PID readings are relative to the calibration gas, usually isobutylene. It is important to calibrate the PID in the same temperature and elevation that the equipment will be used, and to determine the background concentrations in the field before taking measurements. For environments where background readings are high, factory zero calibration gas should be used.

The following subsections will discuss Multi RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

A. Calibration

For Multi RAE configured with O_2, LEL, H_2S, CO, sensors and a 10.6eV PID Lamp.

Start up Instrument

- Press **Mode** button
- Observe displays:

On!……..

Multi RAE
Version X.XX

Model Number
SN XXXX

Date Time
Temp

Checking Sensor
Ids….

VOC Installed

CO Installed

H_2S Installed

OXY Installed

LEL Installed

H_2S VOC CO
LEL OXY

Alarm Limits=

XX XX.X XX
XX High XX.X

XX XX.X XX
XX Low XX.X

XX XX.X XX
STEL

XX XX.X XX
TWA

Battery = X.XV
Shut off at 4.2V

User Mode=

Alarm Mode=

Datalog Time Left

Datalog Mode

Datalog Period

Unit ready in…..
10 Seconds

- The pump will start, the seconds will count down to zero, and the instrument will be ready for use

Calibration Check and Adjustment

Allow instrument to warm up for 15 minutes.

- Depress the **[N/-]** key first, then while depressing the **[N/-]**, depress the **[Mode]** key also and depress both keys for 5 seconds.
- Display will read:

Calibrate
Monitor?

- Press the **[Y/+]** key
- Display will read:

Fresh Air
Calibration?

- If "Zero Air" is necessary, attach the calibration adapter over the inlet port of the Multi RAE Monitor and connect the other end of the tube to the gas regulator (HAZCO loaner regulator LREG.5, RAE Systems P/N 008-3011 or suitable .5 LPM regulator) on the Zero Air bottle (HAZCO P/N SGZA, RAE P/N 600-0024). If no Zero Air is available, perform the Fresh Air Calibration in an area free of any detectable vapor.
- Press the **[Y/+]** key
- Display will read:

Zero….
In progress…

CO Zeroed!
Reading = X

VOC Zeroed!
Reading = X

LEL Zeroed! Reading = X

OXY Zeroed! Reading = X

Zero Cal done!
H_2S Zeroed! Reading = X

In each of the above screens, "X" is equal to the reading of the sensor before it was zeroed.

- Display will then read:

Multiple Sensor Calibration?

- Press the **[Y/+]** key
- The display shows all of the pre-selected sensors and the "OK?" question:

CO H_2S LEL OK? OXY

- Apply calibration gas – use either HAZCO Services Part Number R-SGRAE4 or Rae Systems Part Number 008-3002 – using a .5 LPM regulator and direct tubing.
- Press the **[Y/+]** key. Display will read:

Apply Mixed gas

Calibration In progress …

- The display will count down showing the number of remaining seconds:

CO cal'ed Reading=50

H_2S cal'ed Reading=25

LEL cal'ed Reading=50

OXY cal'ed Reading=20.9

Calibration done Turn off gas!

- Display will read:

```
Single Sensor
Calibration?
```

- Press the **[Y/+]**.
- Display will read:

```
CO VOC H2S
LEL pick? OXY
```

- Attach 100 ppm Isobutylene (HAZCO P/N r-SGISO or Rae P/N 600-0002) using a 1.0 LPM regulator (HAZCO P/N LR10HS or Rae P/N 008-3021). Open regulator.
- Press the **[Mode]** key once, the V of VOC will be highlighted.
- Press the **[Y/+]**. The display will read:

```
Apply VOC Gas
```

```
Calibration
In progress…
```

- The display will count down showing the number of remaining seconds:, then display:

```
VOC cal'd
Reading=100
```

```
Calibration done
Turn off gas!
```

```
Single Sensor
Calibration?
```

- Press **[Mode]** key twice to return to main screen.
- **CALIBRATION IS COMPLETE!**

B. Operation

Due to the Multi RAE having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 9 to 14.

C. Site Maintenance

After each use, the meter should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

D. Scheduled Maintenance

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly

Replace sensors	Biannually or when calibration is unsuccessful

VI. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the field logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g, Multi RAE had wide range fluctuations during air monitoring activities.)

VII. References

Multi RAE Plus Multiple Gas Monitor User Manual, RAE Systems, Revision B1, November 2003.

STANDARD OPERATING PROCEDURE

Installation of Monitoring Wells by Sonic Drilling

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of groundwater monitoring wells and piezometers in unconsolidated or poorly consolidated materials using sonic drilling techniques. Sonic drilling technology eliminates telescoping monitoring wells, allowing the installation of aquifer penetrating, single-cased wells.

II. Equipment and Materials

Drilling

- Sonic drilling rig
- Temporary outer steel casing
- Drill rods and core barrel

Well Riser/Screen

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless steel screen.

Bottom Cap

- PVC, threaded to match the well screen; alternatively, stainless steel
- Centering guides (if used)

Well Cap

- Above-grade well completion: PVC, threaded or push-on type, vented
- Flush-mount well completion: PVC, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets
- Pure, additive-free powdered bentonite

- Coated bentonite pellets; coating must biodegrade within 7 days
- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage

Protective Casing

- Above-grade well completion: 6-inch minimum ID black iron steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to measure pH, temperature, specific conductance, ORP, and dissolved oxygen of development water
- Containers (e.g., 55 gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Drill rods and core barrel with a minimum 8-inch inside diameter (ID) will be used to drill monitoring well boreholes. Continuous core soil samples (6-inches outside diameter) will be collected for lithologic classification and intervals may be selected for chemical analysis. Soil sampling procedures are detailed in SOP *Shallow Soil Sampling.*

The use of water and drilling fluid to assist in sonic drilling for monitoring well installation will be minimized, unless required for such conditions as running sands or drilling bedrock formations.

Temporary outer casing, drill rods, core barrels, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Core barrels and other downhole soil sampling equipment will also be properly decontaminated before and after each use. SOP *Decontamination of Drilling Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the Field Sampling Plan.

B. Monitoring Well Installation

Sonic drilling technology eliminates the necessity to install double or triple cased wells since the borehole will be fully cased during drilling activities. Monitoring wells will be constructed inside the temporary outer casing, once the borehole has been advanced to the desired depth. Following setting the well screen, riser, filter pack, and bentonite seal, the well will be grouted as the temporary casing is withdrawn, preventing cross contamination. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the temporary casing to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 10-slot screen and Morie No. 01 (or DSI No.2) for 20-slot screen silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The temporary casing will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the temporary casing be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained sand pack may be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for the shallow water table and small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table, clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This

will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans), and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing, within the edges of the concrete pad. Guard posts will be concrete-filled, at least 2 inches in diameter, and will extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12-inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

C. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into

the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring well construction (MWSingleDiag.xls)

STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gages in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers)*.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$$

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gages may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gage is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE

VOC Sampling-Water

I. Purpose

To provide general guidelines for sampling aqueous volatile organic compounds.

II. Scope

Standard techniques for collecting representative samples are summarized. Site-specific details are discussed in the Field Sampling Plan.

III. Equipment and Materials

- Sample vials pre-preserved at laboratory with Hydrochloric acid (HCl)
- Surgical or latex gloves

IV. Procedures and Guidelines

1. Sample VOCs before sampling other analyte groups.

2. When sampling for VOCs, especially residential wells, evaluate the area around the sampling point for possible sources of air contamination by VOCs. Products that may give off VOCs and possibly contaminate a sample include perfumes and cosmetics, skin applied pharmaceuticals, automotive products (gasoline, starting fluid, windshield deicers, carburetor cleaners, etc.) and household paint products (paint strippers, thinners, turpentine, etc.).

3. Keep the caps off the sample vials for as short a time as possible.

4. Wear clean latex or surgical gloves.

5. Fill the sample vial immediately, allowing the water stream to strike the inner wall of the vial to minimize formation of air bubbles. DO NOT RINSE THE SAMPLE VIALS BEFORE FILLING.

6. Fill the sample vial with a minimum of turbulence, until the water forms a positive meniscus at the brim.

7. Replace the cap by gently setting it on the water meniscus. Tighten firmly, but DO NOT OVERTIGHTEN.

8. Invert the vial and tap it lightly. If you see air bubbles in the sample, do not add more sample. Use another vial to collect another sample. Repeat if necessary until you obtain a proper sample.

V. Attachments

None.

VI. Key Checks and Items

- Check for possible sources of contamination.
- Fill slowly, with as little turbulence as possible.
- Check for air bubbles.

STANDARD OPERATING PROCEDURE

Aquifer Slug Testing

I. Purpose and Scope

The purpose of this procedure is to outline the equipment and methods that will be used to perform variable-head tests ("slug" tests) on piezometers and monitoring wells. The guidance covers use of both air and solid displacement methods.

II. Equipment and Materials

- In-Situ data loggers or equivalent
- Well-testing assembly
  - packer
  - fittings for pressure transducers
  - fittings for air supply
  - release valve
- Compressed air
- Computer and associated equipment
- Solid displacement device with rope

III. Procedures and Guidelines

The tests to be performed are rising head tests. The tests are accomplished by lowering the head of water in the well and monitoring the recovery of the water level to the static water level. The water level will be lowered by one of two methods. One method is the use of an air displacement device. Alternatively, a solid displacement device removed from the well will be used.

The air displacement apparatus consists of a packer assembly, fittings to accommodate transducers and air pressurization, and a pressure-release valve. The packer is lowered into the upper portion of the monitoring well, secured in place and inflated, providing a seal between the apparatus and the inside of the well. Two fittings are provided for pressure transducers: one transducer is fed through the inside of the device and positioned below the water surface and the other is inserted to measure the air pressure inside the assembly. A third fitting is connected to the pressurized air supply, a compressed air tank.

The datalogger will be programmed to display the air pressure in units of head, the head measured by the submerged transducer, and the difference between the two. The difference between the two pressure transducers is the height of the water column on the submerged transducer. The readings are recorded in a field notebook, and then the assembly is pressurized. The air pressure applied will be equivalent to 3 to 7 feet of head. The pressures are allowed to stabilize. The pressure of the air should not lower the water level to below the base of the bentonite seal installed in the well.

Each test is started by releasing the air pressure inside the assembly and allowing the water level to rise to the static water level. When the datalogger perceives a change in water level in the well above a preset trigger amount, it automatically begins to record the water levels and elapsed time. Each test will be terminated when the water level has recovered to at least 90 percent of the original equilibrium level before pressurization. Note that the test method cannot be used if the well is screened across or near the water table.

An alternate method of lowering the water level is to use a solid displacement device. A single transducer will be installed in the well below the water table. A weighted solid displacement device is added to the well and the water level allowed to stabilize at the original static water level. The test is started by rapidly removing the displacement device, which causes a drop in the water level. The data logger begins recording the water level and elapsed time when the preset trigger amount is reached. Readings are taken as above, and the test stopped when the well has recovered to 90 percent of the original level.

At least two valid tests will be performed in each well. Additional tests will be required if there is some evidence that any of the tests were unacceptable.

At the end of each test, the test results will be transferred to a laptop and the data downloaded and checked for preliminary completeness.

IV. Attachments

None.

V. Key Checks and Preventive Maintenance

- Check that the packer assembly is in good condition and not leaking. Provide a repair kit including tape and clamps. Take additional packer assembly and other spare parts.
- Check the batteries for the datalogger and computer. Check that the computer disks containing the programs for the datalogger are packed.
- Check the datalogger calculation of the well hydraulic conductivity at the end of each test to determine if these are consistent with expectations.

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCl, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well number. A numbering system should be chosen that does not conflict with information recorded for previous exploratory work done at the site. Number the sheets consecutively for each boring.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

Drilling Contractor. Enter the name of the drilling company and the city and state where the company is based.

Drilling Method and Equipment. Identify the bit size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. Technical Data

Depth Below Surface. Use a depth scale that is appropriate for the sample spacing and for the complexity of subsurface conditions.

Sample Interval. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. Number samples consecutively regardless of type. Enter a sample number even if no material was recovered in the sampler.

Sample Recovery. Enter the length to the nearest 0.1-foot of soil sample recovered from the sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil density of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded in this column.

Specific information might include the following:

- The date and the time drilling began and ended each day
- The depth and size of casing and the method of installation
- The date, time, and depth of water level measurements
- Depth of rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, some elements of a complete soil

description, such as the presence of cobbles or boulders, changes in strata, and the relative proportions of soil types in a bedded deposit, can be obtained only in the field.

Soil descriptions should be precise and comprehensive without being verbose. The correct overall impression of the soil should not be distorted by excessive emphasis on insignificant details. In general, similarities rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded for every soil sample collected. The format and order for soil descriptions should be as follows:

1. Soil name (synonymous with ASTM D 2488 Group Name) with appropriate modifiers. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

Examples of acceptable soil names are illustrated by the following descriptions:

- A soil sample is visually estimated to contain 15 percent gravel, 55 percent sand, and 30 percent fines (passing No. 200 sieve). The fines are estimated as either low or highly plastic silt. This visual classification is SILTY SAND WITH GRAVEL, with a Group Symbol of (SM).
- Another soil sample has the following visual estimate: 10 percent gravel, 30 percent sand, and 60 percent fines (passing the No. 200 sieve). The fines are estimated as low plastic silt. This visual classification is SANDY SILT. The gravel portion is not included in the soil name because the gravel portion was estimated as less than 15 percent. The Group Symbol is (ML).

The gradation of coarse-grained soil (more than 50 percent retained on No. 200 sieve) is included in the specific soil name in accordance with ASTM D 2488. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified by describing results from any of the visual-manual procedures for identifying fine-grained soils, such as reaction to shaking, toughness of a soil thread, or dry strength as described in ASTM D 2488.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., GM/SM or SW/SP) can be used to indicate that a soil sample has been identified as having properties that do not distinctly place the soil into a specific group. Generally, the group name assigned to a soil with a borderline symbol should be the group name for the first symbol. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. Moisture Content

The degree of moisture present in a soil sample should be defined as dry, moist, or wet. Moisture content can be estimated from the criteria listed on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained in the Comments column of the soil boring log.

Consistency of fine-grained (cohesive) soil is properly based on results of pocket penetrometer or torvane results. In the absence of this information, consistency can be estimated from N-values. Relationships for determining relative density or consistency of soil samples are given in Tables 3 and 4.

J. Soil Structure, Mineralogy, and Other Descriptors

Discontinuities and inclusions are important and should be described. Such features include joints or fissures, slickensides, bedding or laminations, veins, root holes, and wood debris.

Significant mineralogical information such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

CH2M HILL Form D1586 and a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Feb. 10, 2000. Published May 2000. Originally published as D 2488 – 66 T. Last previous edition D 2488 – 93ϵ1.

[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

***A Summary of Changes section appears at the end of this standard.**

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limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water

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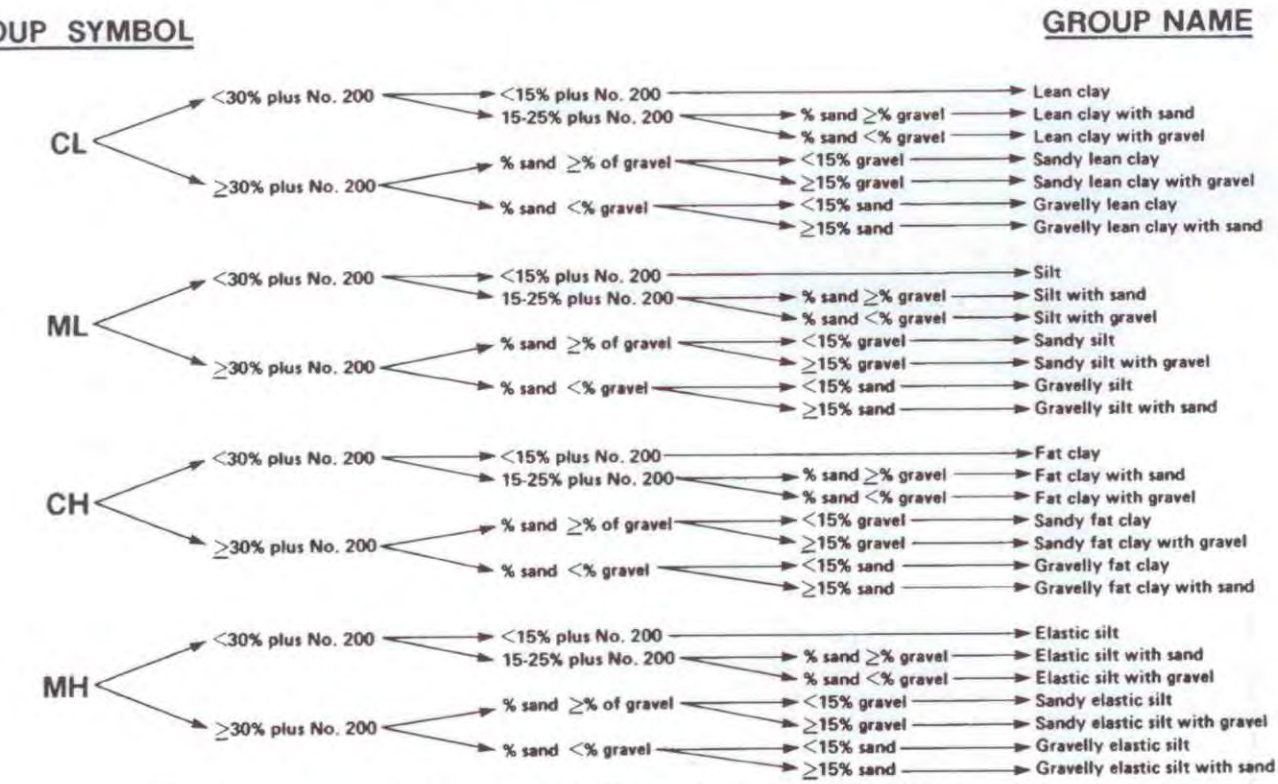
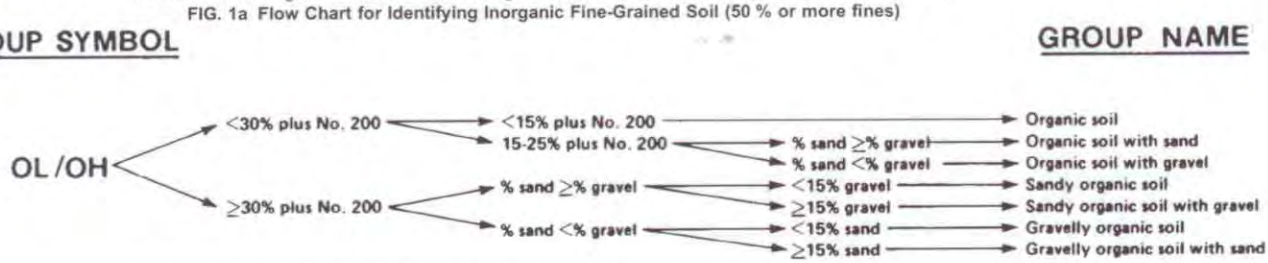


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

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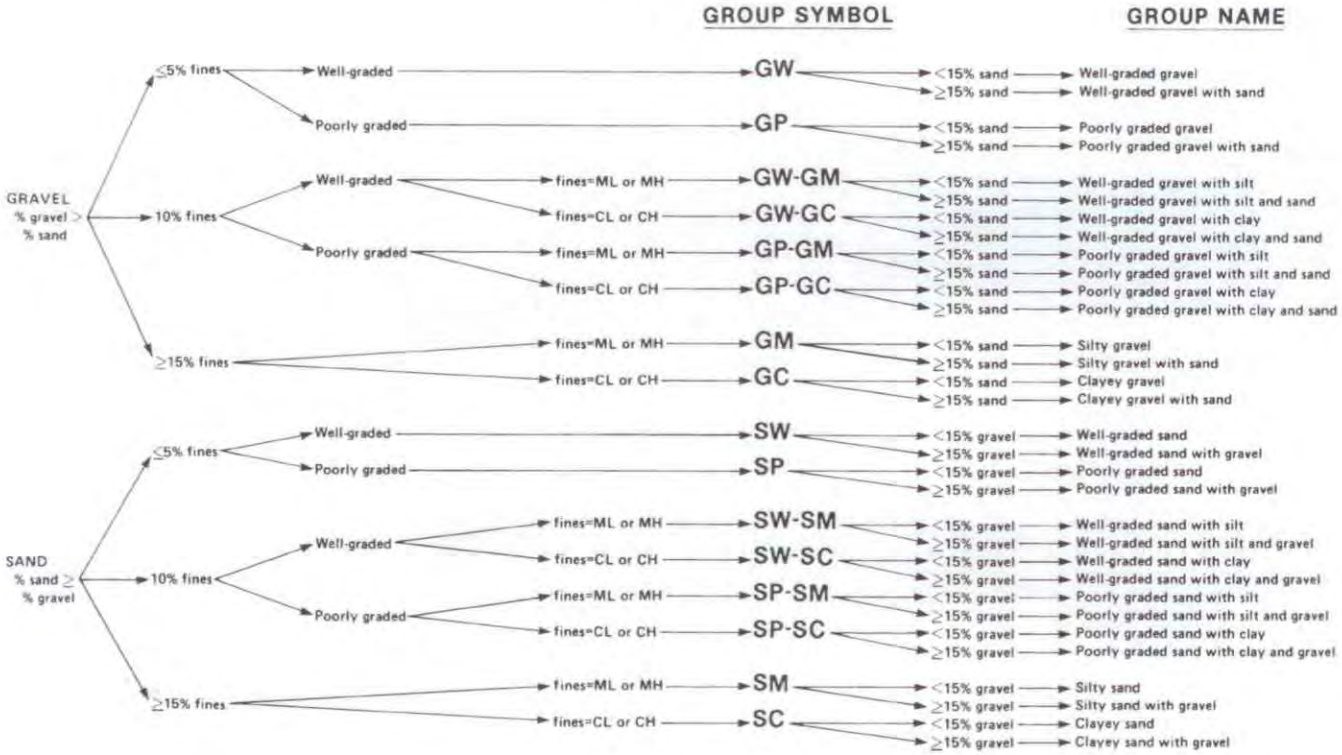

NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

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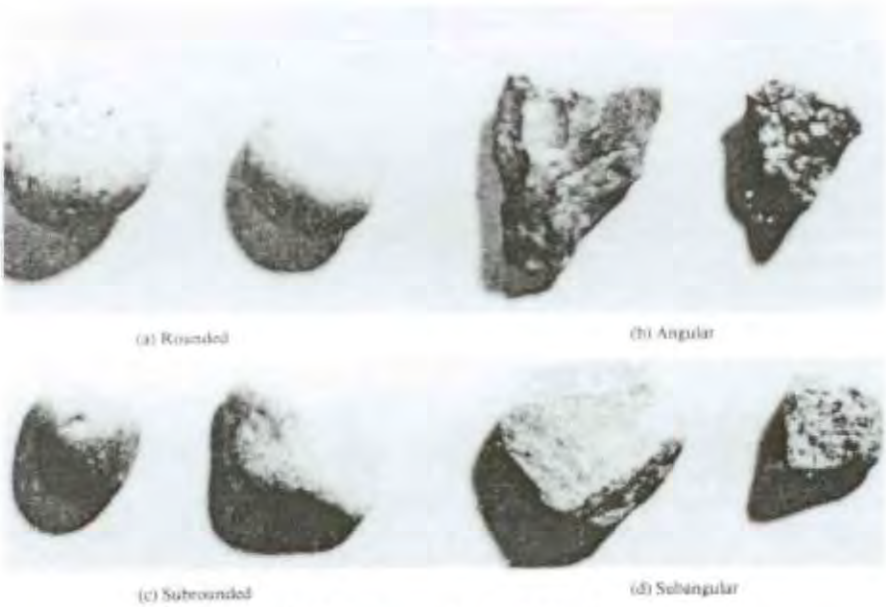

FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

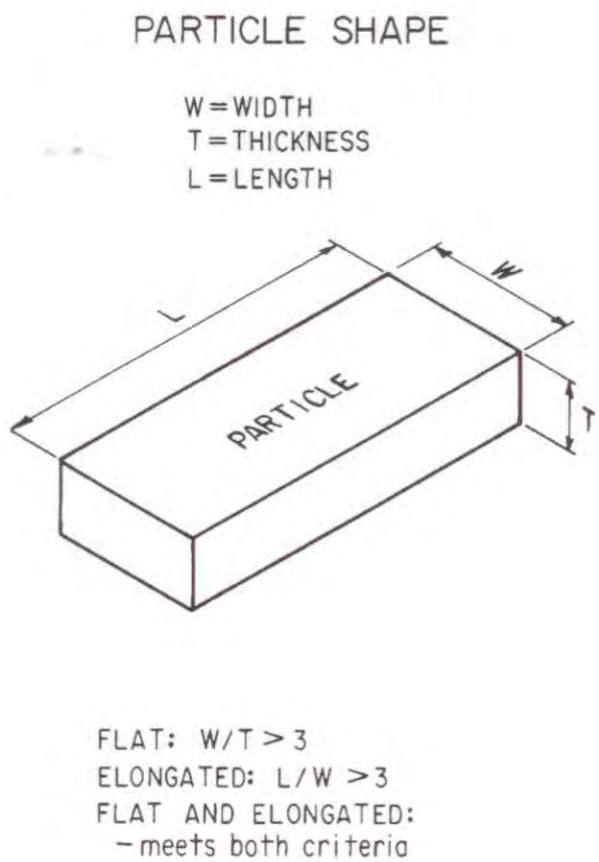

FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

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TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

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medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

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14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

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16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

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angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix: Suffix:

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s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993$^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

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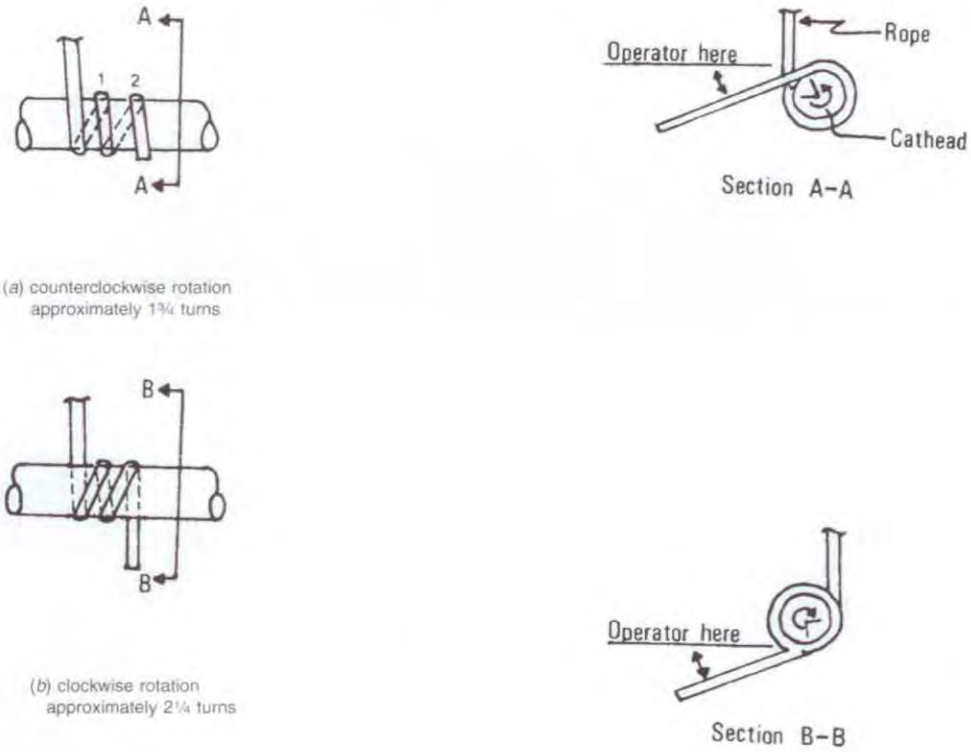

(*a*) counterclockwise rotation approximately 1¾ turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1

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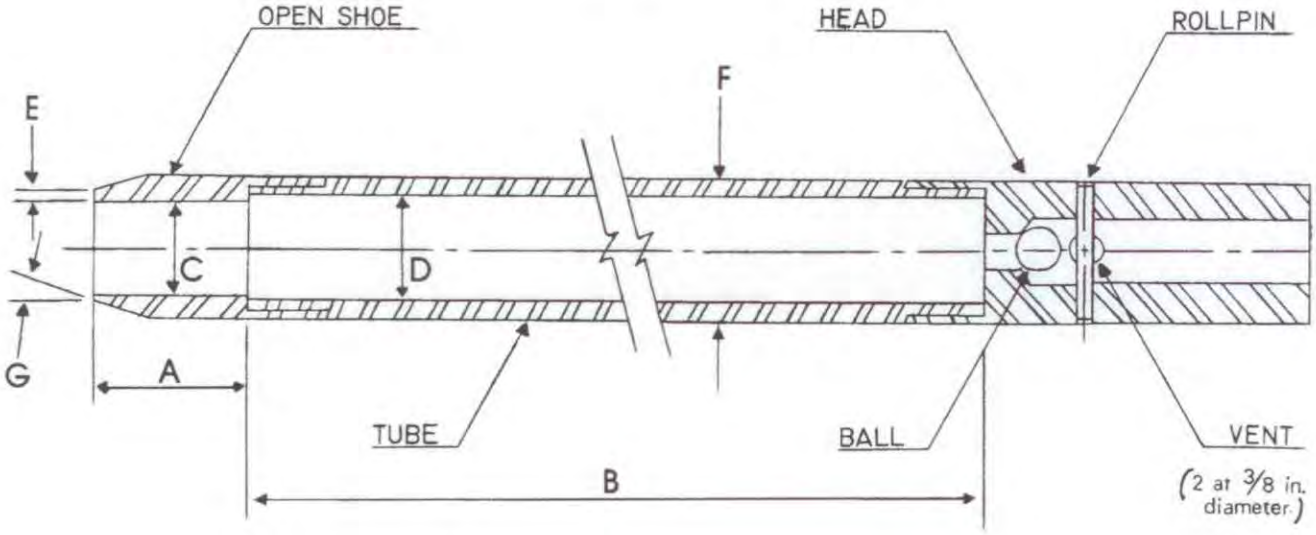

A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly*:

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

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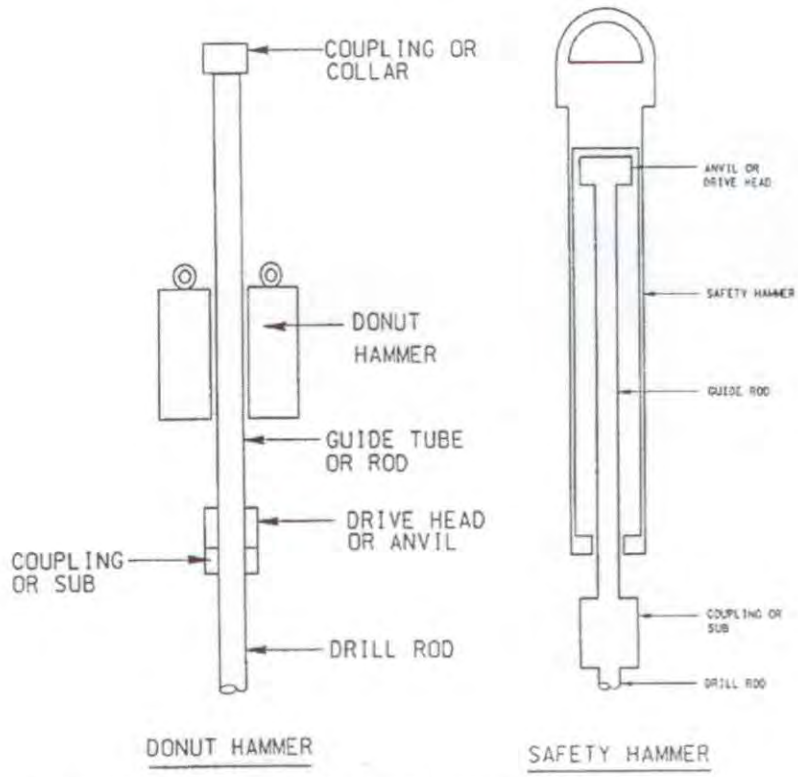

FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

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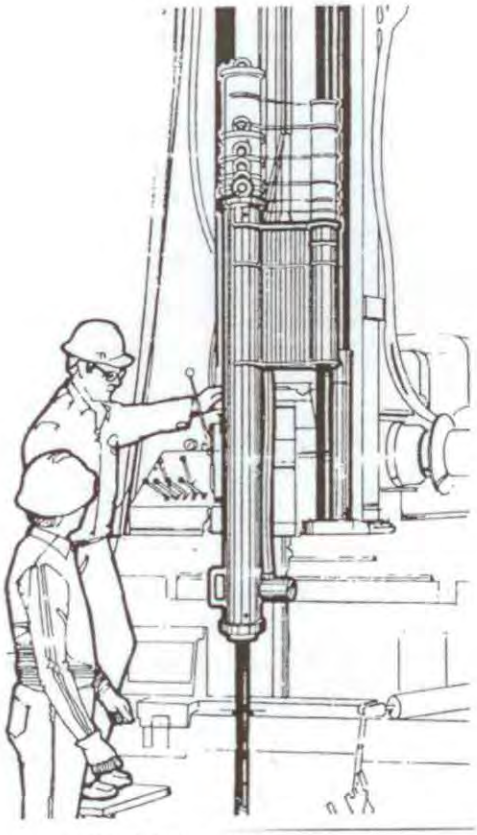

FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

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heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

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APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

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DRILLERS BORING LOG

Project _____ Project No _____ Boring No _____

Location _____ Sheet _____ of _____

Date Started _____ Date Completed _____

Drill Crew:

Boring Location
Station _____ Offset _____

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type _____

Method Of Drilling:

Auger _____ Size _____

Wash _____ Water _____ Mud _____

Hammer Type

Auto _____ Manual _____

Split-Spoon Type

Length _____ Liner Used _____

Boring Size _____ Bit Used _____

Casing Size _____ Length _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____ Time _____

@ _____ Date _____ Time _____

@ _____ Date _____ Time _____

Cave-in Depth

@ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.

(*2*) Scope was completely revised.

(*3*) Referenced Documents updated to include new standards.

(*4*) Terminology: added section on Definitions.

(*5*) Significance and Use: clarified use of the SPT test.

(*6*) Apparatus: general editorial changes.

(*7*) Sampling and Testing Procedure: general editorial changes.

(*8*) Data Sheets/Forms: general editorial changes.

(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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CH2MHILL

PROJECT NUMBER	BORING NUMBER

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

ATD WATER LEVEL : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (IN)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	COPR Strata	SOIL DESCRIPTION	USCS	COMMENTS
						SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.		DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS PID Readings: Breathing Zone: Above Hole:

CH2M HILL

PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT _____ LOCATION _____

ELEVATION _____ DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

WATER LEVELS _____ START _____ FINISH _____ LOGGER _____

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG, FORM D1586

CH2M HILL

PROJECT NUMBER	BORING NUMBER	SHEET 1 OF 3
DEN 22371.G5	BL-3	

SOIL BORING LOG

PROJECT Howard Ave. Landslide LOCATION Howard & 24th Ave, Centennial, CO

ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado

DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig

WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5					
	4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
	5.0					Driller notes very soft drilling 4 ft. dark grey, wet silty cuttings.
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft, strong H_2S odor, many fine roots up to about 1/4 inch	
	8.0					
	10.0	3-ST	1.3	—	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730
						Driller notes rough drilling action and chatter @ 13 ft
	15.0					
15	15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
	20.0					Driller notes smoother, firm drilling @ 19 ft.
20	21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot. tip of 6-S, poss boulders or rock
	23.0					Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

REV 11 89 FORM D1586

Table 1
EXAMPLE SOIL DESCRIPTIONS

POORLY GRADED SAND (SP), light brown, moist, loose, fine sand size

FAT CLAY (CH), dark gray, moist, stiff

SILT (ML), light greenish gray, wet, very loose, some mica, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches max

POORLY GRADED SAND WITH SILT (SP-SM), white, wet, medium dense

ORGANIC SOIL WITH SAND (OH), dark brown to black, wet, firm to stiff but spongy undisturbed, becomes soft and sticky when remolded, many fine roots, trace of mica

SILTY GRAVEL WITH SAND (GM), brownish red, moist, very dense, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, sudden reaction to shaking, layers mostly 1.5 to 8.3 inches thick; LEAN CLAY (CL), dark gray, firm and brittle undisturbed, becomes very soft and sticky when remolded, layers 0.2 to 1.2 inches thick

SILTY SAND WITH GRAVEL (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

SANDY ELASTIC SILT (MH), very light gray to white, wet, stiff, weak calcareous cementation

LEAN CLAY WITH SAND (CL/MH), dark brownish gray, moist, stiff

WELL-GRADED GRAVEL WITH SILT (GW-GM), brown, moist, very dense, rounded gravel to 1.0 inches max

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp, but no visible water
Wet	Visible free water, usually soil is below water table

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Relative Density	Field Test
0-4	Very loose	Easily penetrated with ½-in. steel rod pushed by hand
5-10	Loose	Easily penetrated with ½-in. steel rod pushed by hand
11-30	Medium	Easily penetrated with ½-in. steel rod driven with 5-lb hammer
31-50	Dense	Penetrated a foot with ½-in. steel rod driven with 5-lb hammer
>50	Very dense	Penetrated only a few inches with ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

Blows/Ft	Consistency	Pocket Penetrometer (TSF)	Torvane (TSF)	Field Test
<2	Very soft	<0.25	<0.12	Easily penetrated several inches by fist
2-4	Soft	0.25-0.50	0.12-0.25	Easily penetrated several inches by thumb
5-8	Firm	0.50-1.0	0.25-0.5	Can be penetrated several inches by thumb with moderate effort
9-15	Stiff	1.0-2.0	0.5-1.0	Readily indented by thumb, but penetrated only with great effort
16-30	Very stiff	2.0-4.0	1.0-2.0	Readily indented by thumbnail
>30	Hard	>4.0	>2.0	Indented with difficulty by thumbnail

Attachment 3
Data Management Guidelines

Version 1

Navy CLEAN
Data Management Plan

Prepared for

Navy CLEAN & Joint Venture Programs

December 2009

CH2MHILL

Preface

This document presents the standardized six-step workflow process for environmental data management being performed for the Navy Comprehensive Long-Term Environmental Action - Navy (CLEAN) and Joint Venture Programs. Included in Appendix A is the responsible, approve, support, consult, and inform (RASCI) diagram along with the associated roles and responsibilities, which is the basis for the Navy CLEAN and Joint Venture Programs Data Management Plan (DMP). Following are the six steps in the workflow process:

1. Project planning and database setup
2. Sample collection and management
3. Laboratory analysis
4. Data validation and loading
5. Data management
6. Data evaluation and reporting

Figure P-1 presents a simplified presentation of the workflow process specific to the Navy CLEAN and Joint Venture Programs.

Figure P-2 presents, in more detail, the tools used in each step of the process. CH2M HILL uses the Sample Tracking Sheet (STS) to initiate the sample collection, documentation, and tracking processes. All field-related data is captured in the Field Data Entry Tool (FDETool). During the laboratory analysis and data validation phase, the SNEDD-QC-Tool software will be used to help evaluate the quality of the data. At the data management step, the SVMTool will be used to format the data and the CH-IMPTool will be used to transfer the data into the Navy CLEAN data warehouse. At the data evaluation stage, the XTabReports Tool will be used to query data from the data warehouse, and the Crosstab Cleanup Tool (CCTool) and the Raw, Detects, and Exceedance (RDE) Formatting Tool will produce and format data tables and comparisons to project action levels. Appropriate section(s) of the DMP include additional details on each of the tools used.

Change Management

This DMP is a "living" document and content may be revised or amended to accommodate changes in the scope of environmental investigations or data management requirements that affect the entire Navy CLEAN and Joint Venture Programs. In addition, the DMP appendices will be subject to modification as new or improved methods of data management are developed and implemented.

Any modifications made to the tools will be communicated to the project team via e-mail. As revisions are finalized, they will be distributed electronically to all users. After revision, it is the user's responsibility to conform to revised portions of the DMP.

Amendments will be versioned and released according to the following naming scheme: [Document Name_v#.#_yymmdd]. If a significant change is made to any of these files, the version number will increase by one integer. The revision history is shown in the following table.

REVISION HISTORY

Navy CLEAN and Joint Venture Programs Data Management Plan

Revision Date	Initiator	Purpose

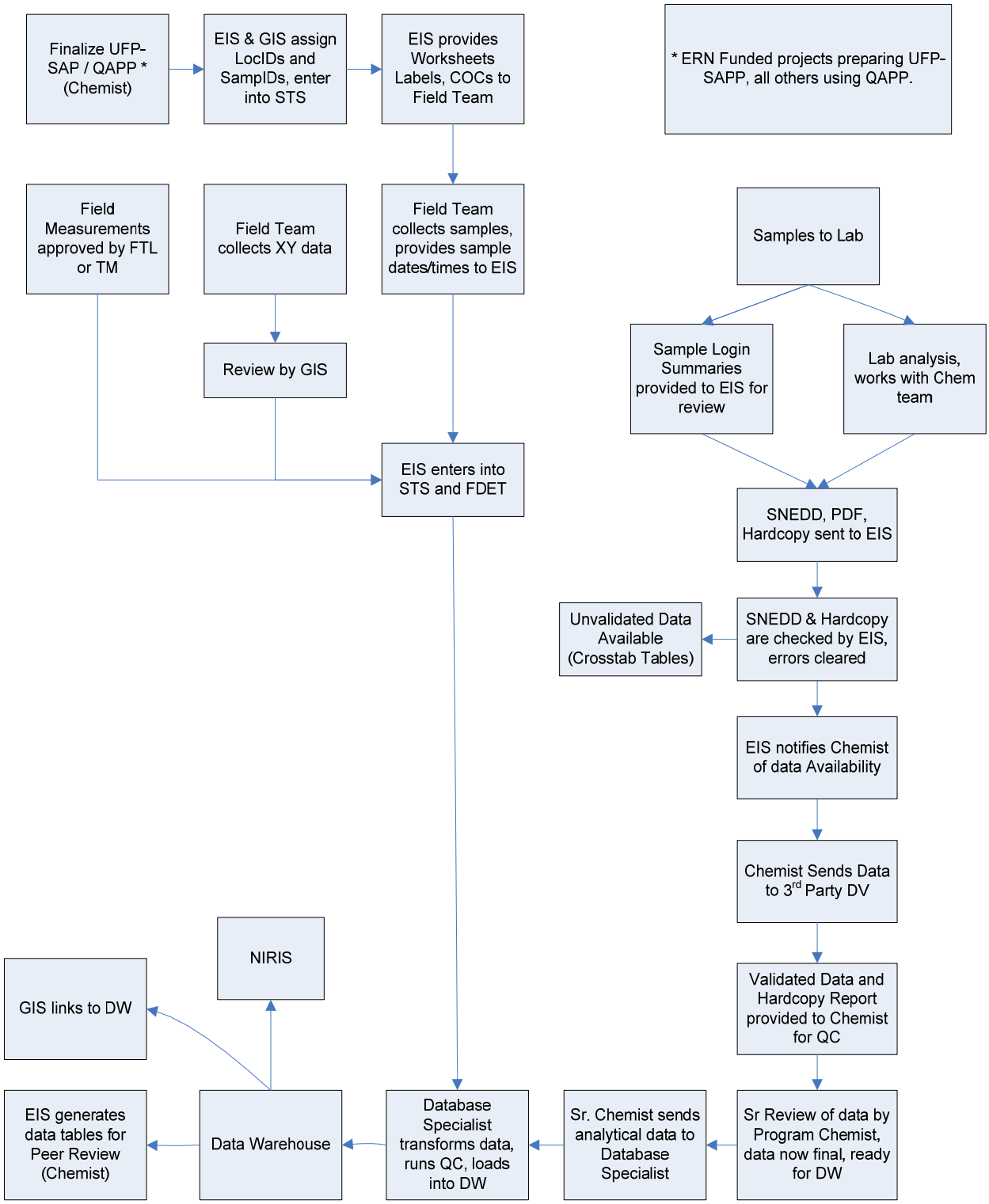

FIGURE P-1
ENVIRONMENTAL DATA MANAGEMENT WORKFLOW PROCESS

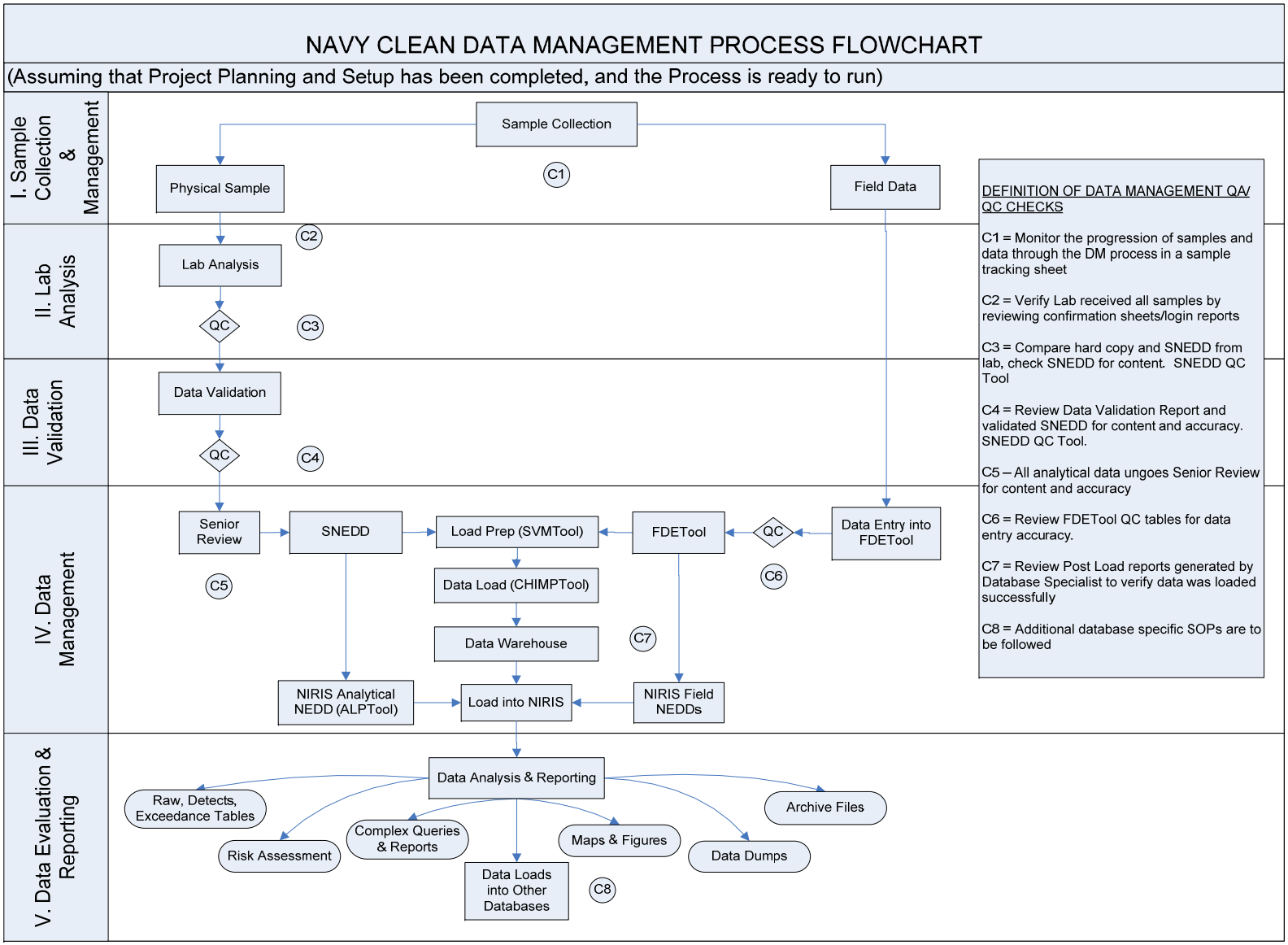

FIGURE P-2
DBMS PROCESS

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Figure 4 Field Sampling **4-4**

Figure 5 Laboratory Analysis **4-2**

Acronyms and Abbreviations

AFCEE	Air Force Center for Engineering and the Environment
ALPTool	Archive Load and Prep Tool
AM	Activity Manager
CAD	computer-aided design
COC	chain-of-custody
DBMS	Database Management System
DBS	Database Specialist
EIS	Environmental Information Specialist
DMP	Data Management Plan
EDD	electronic data deliverable
EDM	Environmental Data Management
EMS	Enterprise Management Solutions
ERP	Environmental Restoration Program
ERPIMS	Environmental Restoration Program Information Management System
EVS	Environmental Visualization System
FD	Field Duplicate
FDETool	Field Data Entry Tool
FTL	Field Team Leader
GA	GIS Analyst
GIS	geographic information system
ID	identification
IDW	investigation-derived waste
IRP	Installation Restoration Program
MS	matrix spike
MSD	matrix spike duplicate
N/FD	normal/field duplicate
NAVFAC	Naval Facilities Engineering Command

NEDD	NIRIS Electronic Data Deliverable
NIRIS	Naval Installation Restoration Information Solution
ODBC	open database connectivity
PC	Project Chemist
PCL	Program Chemistry Lead
PDL	Program Data Management Lead
PGL	Program GIS Lead
PM	Project Manager
QA	quality assurance
QC	quality control
RASCI	responsible, approve, support, consult, and inform
RDM	Regional Database Manager
SDG	Sample Delivery Group
SIMS	Site Information Management System
SNEDD	Supplemental NIRIS Electronic Data Deliverable
SOP	standard operating procedure
STS	Sample Tracking Sheet
SVMTool	SNEDD to VDMS Mapping Tool
VDMS	Validated Data Management System

SECTION 1

Introduction

This Data Management Plan (DMP) describes the methods CH2M HILL will use to manage and present environmental data to support work it is conducting for the Navy CLEAN and Joint Venture Programs. These processes and procedures are part of an overall environmental data management system called the SNEDD Approach to the Validation Data Management System (VDMS), hosted by CH2M HILL.

Project members and any subcontractors supporting program data needs for site characterization and remediation activities can use this DMP. It is a living document that is flexible enough to meet the dynamic needs of the teams and stakeholders. Data management program details and procedures are included in the appendices.

1.1 Purpose

This document outlines how environmental data for the Navy CLEAN and Joint Venture Programs will be obtained and managed using an Enterprise Management Solutions (EMS) approach. The systematic approach will facilitate the retrieval of data from project files and the data warehouse when they are needed, help ensure that the required data are collected and are of the appropriate quality, and help ensure that data records are not lost during transfer to the central program database repository.

1.2 Scope of the Data Management Plan

The scope of the data management activities addressed by this plan includes the following:

- **Roles.** Definition of staff roles and responsibilities.
- **Project Planning and Setup.** Use standard templates and database applications; provide guidance and standard operating procedures (SOPs) for formatting, reviewing, and transferring data collected in the field to the Database Management System (DBMS).
    - **Provide a structured, yet flexible data set.** The DBMS will store all types of environmental data and provides a standard framework for all projects within the Navy CLEAN Program to use. The DBMS is organized and structured, yet flexible enough to allow additional data and data types to be added at any time over the life of the program.
    - **Provide data that are well documented.** The DBMS will retain enough descriptive and source information for technical defensibility and legal admissibility of the data.
- **Sample Collection and Management.** Items that will be captured through standardized forms or applications include chains-of-custody (COCs), field parameter information, groundwater elevation data, and sample tracking records.
- **Laboratory Analysis.** Laboratory data will be reported in the Supplemental Naval Installation Restoration Information Solution (NIRIS) Electronic Data Deliverable (SNEDD)

format specifications that analytical laboratories are required to use to transfer analytical data electronically to CH2M HILL. (Provided to laboratories via a scope of work.) Management and archive procedures will be implemented for hard copy and electronic project documentation.

- **Data Validation.** Internal and external data validation will be conducted in accordance with the appropriate Program and EPA requirements. All deliverables will be subjected to Senior Review quality assurance (QA) and quality control (QC) measures. Management and archive procedures will be implemented for hard copy and electronic project documentation.
- **Data Management.** QA and QC measures will be implemented to provide accurate representation of all data collected and to be stored in the DBMS. QA/QC procedures include restricting data import or entry to specific valid value lists that will not allow incorrect data to be included in the DBMS.
- **Data Evaluation and Reporting.** Reporting and delivery support will be provided from a single DBMS source and allow relatively simple and rapid access to stored data for environmental characterization, report generation, modeling, geographic information system (GIS) mapping, statistical analyses, and risk assessments.
    - **Provide data visualization capabilities.** Data will be accurately represented for use in models, GIS, boring log programs (Environmental Visualization System [EVS), computer-aided design (CAD), graphics, and other software used for mapping, graphing, charting, analyzing, and displaying environmental data.
    - **Provide the ability to compare data electronically.** Tools will allow the electronic comparison of project data to specific reference or screening criteria.
    - **Provide the ability to transfer data to different formats.** The DBMS will provide the ability to reformat, convert, and transfer the data to any format as required by specific end-user applications.

SECTION 2

Roles and Responsibilities

The Navy CLEAN and Joint Venture Programs Environmental Data Management (EDM) team will work together to properly execute the DMP and ensure that the project objectives and scope are realized. The EDM team is composed of data management, chemistry, and GIS resources. The EDM team is responsible for all aspects of planning, execution, management and reporting environmental of data. Data are derived from sampling events related to investigative and remedial activities for Navy CLEAN and Joint Venture projects.

Responsibilities related to data management and information solutions functions are grouped into roles, as listed in Table 1. The SNEDD DM Process Checklist referenced in Appendix C documents the specific responsibilities associated with each of these roles.

TABLE 1
Navy CLEAN and Joint Venture Environmental Data Management Program Team
The Navy CLEAN Program Data Management Plan

Title	Name/Address	Phone	Fax	E-mail
Navy CLEAN Activity Manager (AM)	Various	Various	Various	Various
Navy CLEAN Project Manager (PM)	Various	Various	Various	Various
Field Team Leader (FTL)	Various	Various	Various	Various
Program Critigen Team Lead	Mike Dierstein 5700 Cleveland Street Suite 101 Virginia Beach, VA 23462	757-671-6216	757-497-6885	mdierste@critigen.com
Program Data Management Lead (PDL)	Chelsea Leigh 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6208	773-695-1378	cleigh@critigen.com
Database Specialist (DBS)	Bhavana Reddy 15010 Conference Center Dr. Suite 200 Chantilly, VA 20151	703- 462-3784	703- 376-5010	breddy@critigen.com
Program Chemistry Lead (PCL)	Anita Dodson 5700 Cleveland Street Suite 101 Virginia Beach, VA 23462	757-671-6218	757-497-6885	adodson@ch2m.com
Project Chemist (PC)	Mike Zamboni 15010 Conference Center Dr. Suite 200 Chantilly, VA 20151	703-376-5111	703-376-5801	mzamboni@ch2m.com
Project Chemist (PC)	Megan Morrison 15010 Conference Center Dr. Suite 200 Chantilly, VA 20151	703-376-5053	703-376-5801	megan.morrison@ch2m.com

TABLE 1
Navy CLEAN and Joint Venture Environmental Data Management Program Team
The Navy CLEAN Program Data Management Plan

Title	Name/Address	Phone	Fax	E-mail
Project Chemist (PC)	Bianca Kleist 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6281	757-497-6885	bkleist@ch2m.com
Project Chemist (PC)	Juan Acaron 3011 S.W. Williston Road. Gainesville, FL 32608	352-384-7002-		juan.acaron@ch2m.com
Project Chemist (PC)	Kristina Lambert 3011 S.W. Williston Road. Gainesville, FL 32608	352-335-5877		kristina.lambert@ch2m.com
Environmental Information Specialist (EIS)	Genevieve Moore 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6284	757-497-6885	gmoore@ch2m.com
Environmental Information Specialist (EIS)	Rebekha Shaw 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6279	757-497-6885	rshaw22@ch2m.com
Environmental Information Specialist (EIS)	Gwendolyn Buckley 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-8311	757-497-6885	Gbuckle1@ch2m.com
Environmental Information Specialist (EIS)	Victoria Brynildsen 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6252	757-497-6885	vbrynildsen@ch2m.com
Program GIS Lead (PGL)	Mike Dierstein 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6216	757-497-6885	mdierstein@critigen.com

TABLE 1
Navy CLEAN and Joint Venture Environmental Data Management Program Team
The Navy CLEAN Program Data Management Plan

Title	Name/Address	Phone	Fax	E-mail
GIS Analyst (GA)	Blake Hathaway 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6230	757-497-6885	bhathawa@critigen.com
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GIS Analyst (GA)	Mark Unwin 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6261	757-497-6885	munwin@critigen.com
GIS Analyst (GA)	Chris Bowman 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6276	757-497-6885	cbowman@critigen.com
GIS Analyst (GA)	Matt Rissing 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6243	757-497-6885	mrissing@critigen.com
GIS Analyst (GA)	Forrest Cain 5700 Cleveland Street. Suite 101 Virginia Beach, VA 23462	757-671-6271	757-497-6885	fcain@critigen.com

SECTION 3

Data Management System Description

During field investigation, monitoring, and remedial activities, CH2M HILL will collect a variety of environmental information to support data analysis, reporting, and decision-making activities. To meet current regulatory QA requirements, a complete audit trail of the information flow must be implemented. The six steps in the workflow process are (Appendix B):

1. Project planning and database setup
2. Sample collection and management
3. Laboratory analysis
4. Data validation
5. Data management and loading
6. Data evaluation and reporting

Each step in the data management process must be adequately planned, executed, and documented. Figure 1 presents a simplified presentation of the workflow process specific to the Navy CLEAN and Joint Venture Programs. Figure 2 presents, in more detail, the tools used in each step of the process.

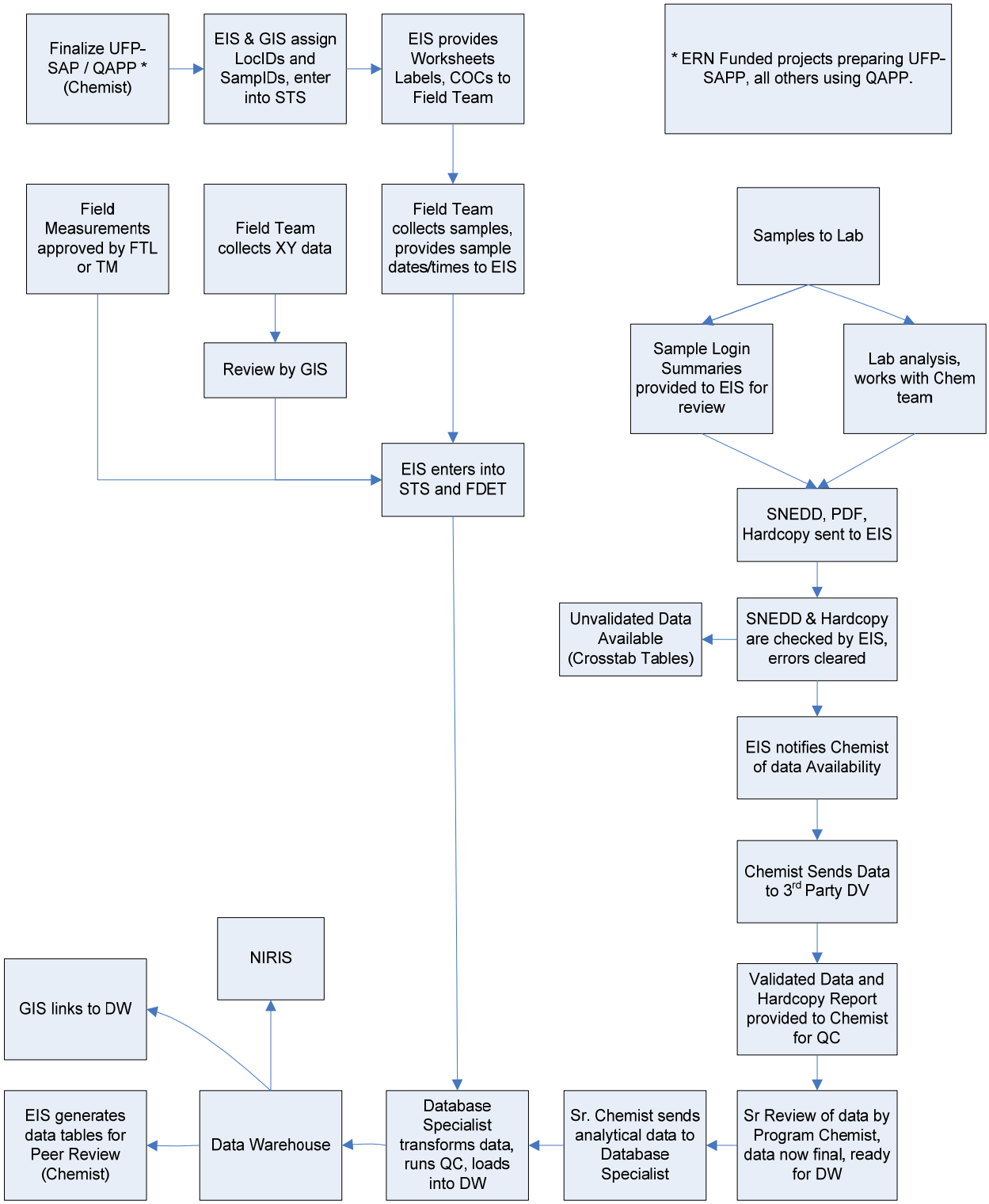


FIGURE 1
ENVIRONMENTAL DATA MANAGEMENT WORKFLOW PROCESS

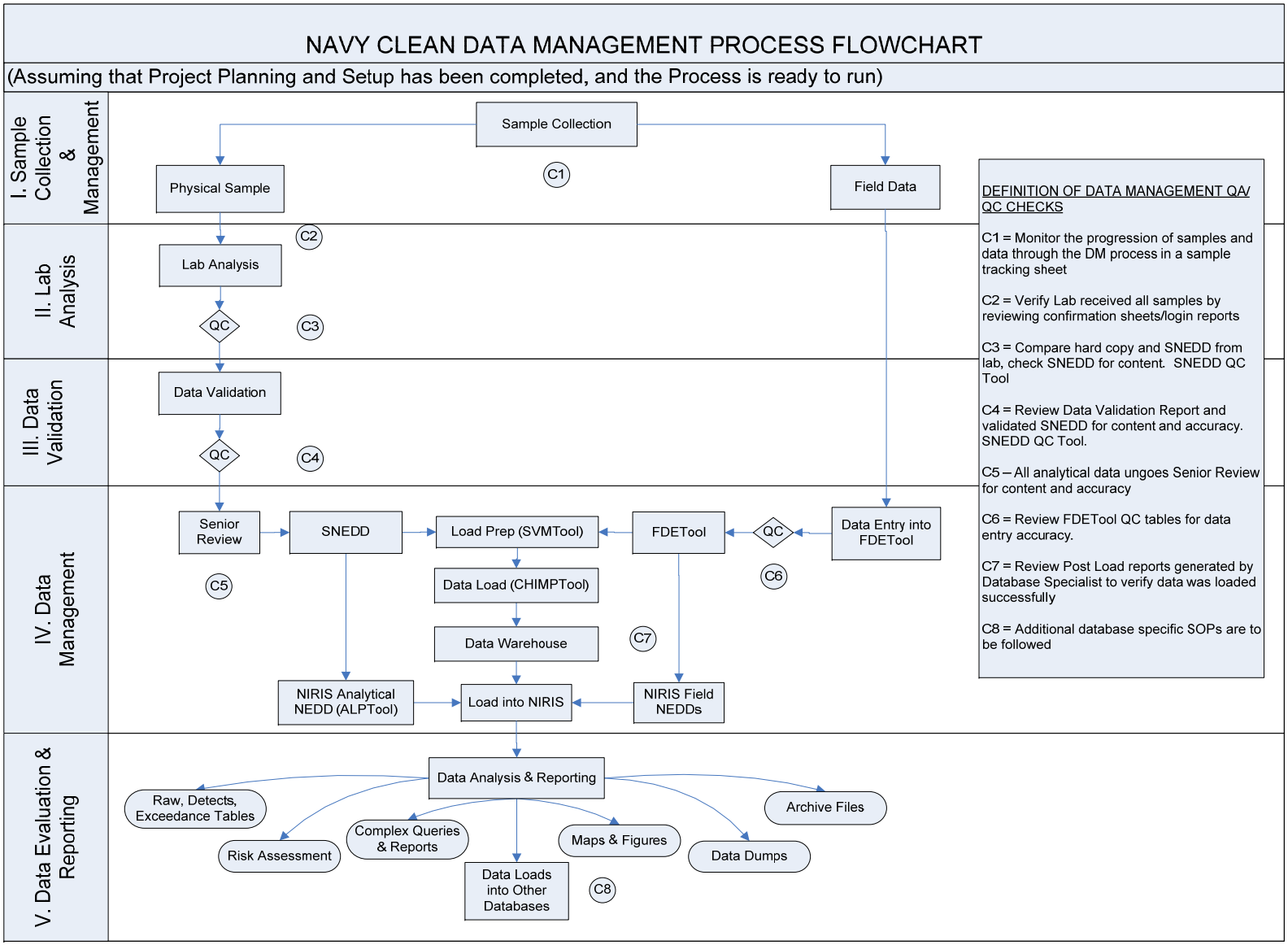


FIGURE 2
DBMS PROCESS

SECTION 4

Phases of Data Management

4.1 Project Planning and Setup

Project planning starts when a new project or task is identified in the program. Evaluation of what is required from data management and visualization occurs to determine the data needs. The Program Critigen Team Lead (Critigen Lead) works with the Program Data Management Lead (PDL) and the project and/or activity manager to determine what is expected and required from the data management and visualization team. Specific items that should be considered are as follows:

- Inputs – Determine what data will be collected and stored in the database. Determine frequency and quantity. Determine what tools will be used to handle data input.
- Historical Data – This is a unique data input and requires special consideration. The PDL ***must*** work with the other technical leads to assess what effort will be required. This step is often missed, and the resulting data quality issues created from inadequate planning in this area can plague the project for its entire duration.
- Outputs – Determine what data will need to be presented in reports, figures, and electronic deliverables. Determine frequency and quality requirements. Determine preliminary data, validated data, and what tools will most effectively handle the output requirements. Discuss how the outputs needed by the team will be requested and documented.
- Visualization – Determine necessity for GIS and CAD.

After the information above is determined, the data management scope, schedule, and budget are developed and endorsed by the Project Manager (PM), PDL, Program GIS Lead (PGL) and Program Chemistry Lead (PCL). The team can then proceed upon client authorization of the overall project budget. Figure 3 shows the process for project planning.

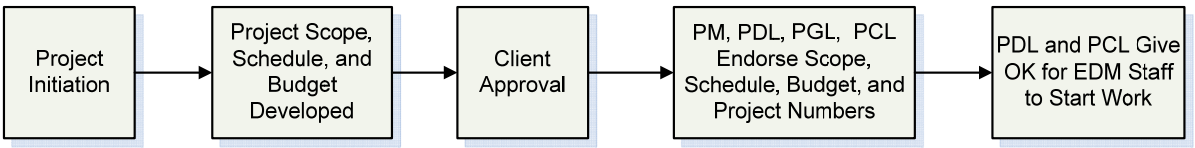


FIGURE 3
PROJECT PLANNING

4.1.1 Database Setup and Administration

CH2M HILL Database

The PDL will oversee the administration of the DBMS, including the design, development, and maintenance of the program database, tools and data management processes. Database and data management process design and development will focus on providing rapid data entry

and data retrieval while promoting data integrity through various automated procedures. The PDL will perform the database maintenance, which consists of the following:

- Assisting with the allocation of sufficient system storage for the program database
- Adding, altering, and deleting users, roles, and privileges
- Periodically defragmenting and compacting the database for more efficient operation
- Upgrading database software and associated applications as necessary
- Maintaining an approved list of valid values for data consistency
- Maintaining redundancy control to ensure that each data record is unique and consistent with conventions
- Performing routine virus checks on incoming and outgoing data

The DBMS is comprised of the Data Warehouse and associated SNEDD-Approach tools, and will support the storage, analysis, display, and reporting of the Navy's environmental, analytical, and geotechnical data. The DBMS will consist of primary data tables that store the environmental data, dependent tables that store more details related to the data in the primary tables, and look-up tables that store valid values to provide input to the primary tables. The EIS will maintain the table content and the PDL will manage it.

Valid values are critical to any large relational database. Tables 2 and 3 provide examples of valid values for the Navy CLEAN and Joint Venture Programs' sites, stations, and samples. Inconsistencies in naming conventions, subtle analyte or method spelling differences, and the use of non-standard abbreviations can result in lost data and incorrect conclusions. Most tables and forms in the program database will use look-up tables for acceptable valid values and will not allow the entry of data that do not conform.

The primary purpose of managing data in a relational database environment is to ensure that each data record is unique and that the information contained within each field is consistent with conventions defined in other areas of the database. To ensure that each record is unique, a key field or fields will be identified within each data table. The VDMS Data Warehouse architecture supports this approach and eliminates the possibility of data redundancy.

NIRIS Database

All Navy CLEAN and Joint Venture data must be loaded into the Navy's own internal database system, the Naval Installation Restoration Information Solution (NIRIS). NIRIS is a web-based centralized database that has been implemented across all Naval Facilities Engineering Command (NAVFAC) offices and will be used by the Navy and contractors to manage, evaluate, and visualize data, documents and records for Navy and the Marine Corps sites. NIRIS manages all Environmental Restoration Program (ERP) analytical and spatial data, which includes the Munitions Response and Installation Restoration Program (IRP) data, ensuring institutional memory is preserved, land use controls are maintained, and remedial actions are effective.

CH2M HILL will use the SNEDD Approach to VDMS system to track, collect, review, and prepare Navy-related sample and project data for loading into NIRIS. Project data stored in the

VDMS Data Warehouse must be consistent and comparable with data that is loaded and stored within NIRIS. As such, all associations between VDMS and NIRIS valid values, output reports, and data tables will be tracked and maintained.

4.1.2 Data Security Procedures

Some SNEDD Approach to VDMS applications and data are stored in a secure location with login and password protection. Authorized users will have logins and passwords in advance. The PDL will provide security access to these tools. Access2003 must be installed on the computer that the user will be using to run these applications, and proper licenses distributed. Files received from any subcontractors will be scanned for common viruses using industry standard, current virus protection programs. The file servers storing the data must be running current virus software, with automatic virus signature updates.

NIRIS data are stored in a secure location with login and password protection. Users who require access to NIRIS and the data contained therein will need to follow procedures outlined in the SOP Access to NIRIS to procure security certificates, training, and access rights to installation-specific data. Authorized users of NIRIS will be assigned logins and passwords maintained by the Navy. For further information on NIRIS or obtaining NIRIS access, consult with the Critigen Lead or PDL.

4.1.3 Data Backup and Recovery

All project data management files will reside on CH2M HILL's terminal server, "Gaia," and will have a tape backup or equivalent created in accordance with CH2M HILL's network server management policy.

4.2 Sample Collection and Management

Sample control during the sampling phase is required to ensure the integrity of the associated data. Sample control must be maintained and documented from the point of collection through the point of disposal. Sample control will be managed both in the field and in the laboratory, and will be documented using field logbooks and a Chain of Custody (COC). When custody of a sample is transferred from one party to another, the recipient of the sample assumes responsibility for maintaining control of the sample and documenting that control on the COC. Figure 4 shows the process for planning and executing field sampling events.

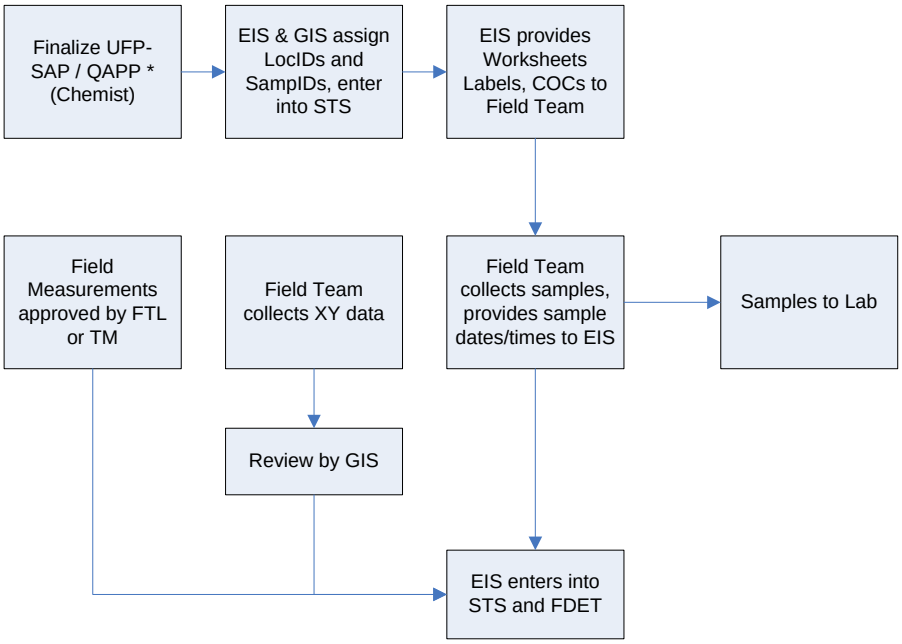


FIGURE 4
FIELD SAMPLING

4.2.1 Sample Tracking Sheet

During the planning stage, the PM specifies the data requirements for the sampling event. The work plan or similar document will provide project-specific data requirements for a given sampling event. The Project Chemist (PC) is responsible for reviewing the Sampling and Analysis Plan and ensuring that the FTL is aware of the number of field and laboratory QC samples required for the sampling event (trip blanks, equipment blanks, field blanks, field duplicates, matrix spikes, and matrix spike duplicates). All of this information is to be entered into the STS.

The STS will be used in advance to identify sampling container and preservation requirements, identify analytical laboratories for samples, aid in the generation of labels for sample bottles before the sampling event, and prepare COC forms after sampling is complete.

4.2.2 Sample Nomenclature Guidelines

The following guidelines are provided for sample nomenclature, COC clarification, and eData expectations.

Station ID (Location)

Field station data are information assigned to a physical location in the field at which some sort of sample is collected. For example, a monitoring well that has been installed will require a name that will uniquely identify it with respect to other monitoring wells or other types of sample locations. The station name provides a key in a database to which any samples collected from that location can be linked to form a relational database structure.

Before beginning fieldwork, the FTL will review the proposed level of effort and coordinate a list of unique station identification names, or station IDs, with the PDL or EIS. The FTL will be

responsible for enforcing the use of the standardized ID system and agreed upon station IDs during all field activities.

Each station will be uniquely identified by an alphanumeric code that will describe the station's attributes. These attributes are facility, Area of Concern (AOC)/Site/Operable Unit (OU) number, station type, sequential station number, and possibly an additional qualifier as needed. The naming scheme to be used for the identification of a sampling station is documented in Table 2.

For example, if the first sample location at next month's event within Yorktown Site 30 is at a soil location, then the location ID could possibly be YS30-SO391 because that was the next available sequence number for soil locations. This should also be reflected in the Sample ID. QC and IDW station IDs must be established for each site that they are associated with.

Please consult with the PDL or EIS should any questions arise. This will avoid complications that could occur if a station is mislabelled and ensure there are unique identifiers for every sampling location. Required deviations to this format in response to field conditions will be documented in the field logbook.

Sample ID

Field sample data are information assigned to a physical piece of material collected in the field for which some sort of analysis will be run. Before collecting samples, the FTL will review the proposed level of effort and coordinate a list of unique sample identification names, or sample IDs, with the PDL or EIS. The FTL will be responsible for enforcing the use of the standardized ID system and agreed upon sample IDs during all field activities.

Each sample will be uniquely identified by an alphanumeric code that will describe the sample's attributes. These attributes are facility, Area of Concern (AOC)/Site/Operable Unit (OU) number, sample/station type, sequential station number, modifier (as needed), depth (as needed), date, and date modifier (as needed). The naming scheme to be used for the identification of samples is documented in Table 3.

The standardized ID system will identify all samples collected during sampling activities. The system will provide a tracking procedure to ensure accurate data retrieval of all samples taken. For example, a surface soil sample collected from station YS30-SO391 reference above in June of 2009 will result in a sample ID of YS30-SS391-0609.

Please consult with the PDL or EIS should any questions arise. This will avoid complications that could occur if a sample is mislabelled and ensure there are unique identifiers for every sample. Required deviations to this format in response to field conditions will be documented in the field logbook.

Navy Clean		
First Segment	**Second Segment**	
Facility, Site Number	Station Type	Station Number, Modifier
AA,ANN	AA	NNN_A
Notes: "A"= alphabetic "N"= numeric		

Facility:

A = ABL
AN = Anacostia
BA = Bainbridge
BW = Bloodsworth Island
BR = Bremerton
CA = Cheatham Annex
CH = Cherry Point
CI = Craney Island
CL = Camp Lejeune
CP = Camp Peary
CR = Carderock
DA = Dahlgren
DN = Dam Neck
DR = Driver
IH = Indian Head
LS = Little Creek
NA = Naval Academy
NB = Naval Station Norfolk
NM = NNMC (Bethesda Naval Hospital)
NN = Norfolk Naval Shipyard
NR = Naval Research Laboratory
NWA = Northwest Annex
OC = Oceana
PA = Pax River
PI = Pineros Islands
QU = Quantico
RO = Rota
RR = Roosevelt Roads
SI = Sigonella
SJ = St. Juliens
SS = Sabana Seca
VE = Vieques East
VW = Vieques West
WN = Washington Navy Yard
WO = White Oak
Y = Yorktown

Site/AOC/SWMU Number – Sequential Number:

Site = S01, S02, S03…
Site Screening Area = SA01, SA02, SA03…
AOC = A01, A02, A03…
AOI = AI01, AI02, AI03…
SWMU = W01, W02…
Building = B01, B02, B03…
Range = R01, R02…
LIA – LI Area, East Vieques

BSxx = Background locations outside of site (BS25 = Background Site 25)
BKL = Background locations outside of the facility
BKG = Background locations (inside base)

QC and IDW Stations
Site ID (First Segment) followed by –QC or -IDW

Station Type:

AGT = Above Ground Tank
AS = Ash
BH = Borehole
CO = Concrete
DP = Direct Push
DR = Drill Rig
EW = Extraction Well
FG = Frog
FS = Fish
GB = Geotechnical Boring
GP = Geoprobe
GV = Gas Vent
HP = Holding Pond/Lagoon
IDW = Investigative Derived Waste
IW = Injection Well
LW = Leach Well
MA = Alluvial Monitoring Well
MB = Bedrock Monitoring Well
MU = UST Monitoring Well
MW = Monitoring Well (GW for Y)
PC = Paint Chip
PW = Production Well
QC = Quality Control
RK = Rock
RC = Recovery Well
RM = Remediation Well
RW = Residential Well
SD = Sediment Location
SG = Soil Gas
SL = Storm Sewer Line Sediment
SO = Soil Location
SP = Seep
ST = Storm Water
SU = Sump
SV = Soil Vapor
SW = Surface Water
SWS = Surface Water Body (for SW and SD)
UST = Underground Storage Tank
TA = Tap Water
TD = Tidal Station
TI = Tissue Sample (general)
TO = Tadpole
TP = Test Pit
TR = Trench Sediment
TS = Treatment System
TW = Temporary Well
WA = Alluvial Extraction Well
WB = Bedrock Extraction Well
WL = Water Supply Well
WN = Pore Water
WP = Wipe Sample
WT = Water Table Piezometer

Station Number:
Sequential Station Number (i.e., 01, 02, 03…)

Modifier (used selectively):
D = Deep monitoring well
S = Shallow monitoring well

Example Station IDs:

YS01-DP02 = Direct push soil location #2 at Yorktown Naval Weapons Station Site 1
CHR05-MW02S = Shallow monitoring well location 2, at the Cheatham Annex facility, Range 5.
NMBKL-SD02 = Background sediment location #2 located outside of NNMC
CHBS03-SO05 = Soil location #5, located in reference area outside of Site 3 in Cherry Point
VEW04-QC = QC Station at East Vieques SWMU-4
CAA08-IDW = IDW Station at Cheatham Annex AOC-8

TABLE 2

STATION ID SCHEME

Navy Clean			
First Segment	**Second Segment**	**3rd Segment**	**Fourth Segment**
Site ID Facility, AOC Number	Station/Sample Type, Station Number, Modifier	Depth (As Needed)	Date (MMYY) $_A$
AA,ANN	AANNN$_A$	A	NNNN$_A$
Notes: "A"= alphabetic "N"= numeric			

A = ABL
AN = Anacostia
BA = Bainbridge
BW = Bloodsworth Island
BR = Bremerton
CA = Cheatham Annex
CH = Cherry Point
CI = Craney Island
CL = Camp Lejeune
CP = Camp Peary
CR = Carderock
DA = Dahlgren
DN = Dam Neck
DR = Driver
IH = Indian Head
LS = Little Creek
NA = Naval Academy
NB = Naval Station Norfolk
NM = NNMC (Bethesda Naval Hospital)
NN = Norfolk Naval Shipyard
NR = Naval Research Laboratory
NWA = Northwest Annex
OC = Oceana
PA = Pax River
PI = Pineros Islands
QU = Quantico
RO = Rota
RR = Roosevelt Roads
SI = Sigonella
SJ = St. Juliens
SS = Sabana Seca
VE = Vieques East
VW = Vieques West
WN = Washington Navy Yard
WO = White Oak
Y = Yorktown

Site/AOC/SWMU – Sequential Number:

Site = S01, S02, S03…
Site Screening Area = SA01, SA02, SA03…
AOC = A01, A02, A03…
AOI = AI01, AI02, AI03…
SWMU = W01, W02…
Building = B01, B02, B03…
Range = R01, R02…
LIA – LI Area, East Vieques

BSxx = Background locations outside of site (BS25 = Background Site 25)
BKL = Background locations outside of the facility
BKG Background locations (inside base)

Sample Type:
AGT = Above Ground Tank
AH = Air - Headspace
AS = Ash
BH = Borehole
CO = Concrete
DR = Drill Rig
DS = Direct Push—Soil
DW = Direct Push—Groundwater
EW = Extraction Well
FG = Frog
FS = Fish
GB = Geotechnical Boring
GP = Geoprobe
GV = Gas Vent
HP = Holding Pond/Lagoon
IW = Injection Well
LF = Free Product
LW = Leach Well
MA = Alluvial Monitoring Well
MB = Bedrock Monitoring Well
MU = UST Monitoring Well
MW = Monitoring Well (GW for Y)
PC = Paint Chip
PW = Production Well
RK = Rock
SW = Surface Water
RC = Recovery Well
RM = Remediation Well
RW = Residential Well
SB = Subsurface Soil
SD = Sediment Location
SG = Soil Gas
SL = Storm Sewer Line Sediment
SO = Soil Location (Composite)
SP = Seep
SS = Surface Soil
SSD = Subsurface Sediment
ST = Storm Water
SU = Sump
SV = Soil Vapor
SW = Surface Water
UST = Underground Storage Tank
TA = Tap Water
TD = Tidal Station
TI = Tissue Sample (general)
TO = Tadpole
TP = Test Pit
TR = Trench Sediment
TS = Treatment System
TW = Temporary Well
WA = Alluvial Extraction Well
WB = Bedrock Extraction Well
WL = Water Supply Well
WN = Pore Water
WP = Wipe Sample
WT = Water Table Piezometer

Station Number:
Sequential Number (e.g., 001, 002, 003)

Modifier (used selectively):
D = Deep monitoring well
S = Shallow monitoring well
P = Duplicate

Depth:

Use only if applicable. A sequential letter is used to reflect varying depths, as actual depths can change in the field after sample planning has occurred. E.g. A, B, C…

Sample Number:

1. Duplicate Samples - Use a 'P' modifier in the second segment of the sample ID, directly after the location number to indicate a duplicate sample. E.g. AB01-MW11P-0506

2. MS/MSD Samples – Append a modifier of '-MS' for matrix spike or '-SD' for matrix spike duplicate to the end of the sample ID.

3. QC & IDW Samples (Blank Samples & Waste Char.) - Format consists of Facility, AOC Number, Qualifier Code, Sequential Qualifier Number-Date (AAANN-AANN-MMDDYY). E.g. LSA05-TB02-061106

Qualifier Codes:
TB = Trip Blank
FB = Field Blank
EB = Equipment Blank
WQ = Source Blank
WS = Waste Char. Soil
WW = Waste Char. Water

4. Drill Rig Samples – Format consists of Facility, AOC Number, Station Type, Station Number, Date. E.g. YS12-DR02-020507

5. Multiple samples - Should multiple samples be collected from the same location in a given day/month (affects only samples not differentiated by depth), a sequential letter will be added to the end of the fourth segment (date). E.g. A, B, C…

Example Sample IDs:

WNA01-MW102S-0105A = The first shallow groundwater sample collected at monitoring well location 102 in January 2005 in AOC01 at the Washington Navy Yard facility.
PIW01-SW023P-0306 = Pineros Island duplicate surface water sample collected at location 23, at SMWU-1 in March 2006.
SSW06-FB01-061106 = The first field blank collected on June 11, 2006 at SMWU-6 in Sabana Seca.

TABLE 3

STATION ID SCHEME

4.2.3 Sample Collection

A photocopy of each field logbook page completed during sampling and of each COC will be made by the FTL and forwarded to the EIS at predefined intervals during sampling events. This information will serve as notification to the EIS of samples being shipped to an offsite lab and of the field crew's sampling progress.

Communication with field and laboratory staff will occur daily during the field event. The EIS will resolve issues that arise in the field (i.e. bottle ware shortage, equipment failure, etc). The lab will be informed of the shipment dates and the number of coolers or samples being sent. Laboratory login reports will be reviewed to ensure samples were received in good condition (i.e. no breakage, within holding time, within designated temperature). The field crew and PM will be notified if there were problems with shipment.

4.2.4 Chain-of-Custody

A single COC number per laboratory / cooler should be generated each day (there can be multiple pages to one COC number). MSs and MSDs will be requested at a set frequency for each project (usually one per 20 samples collected). MS and MSD samples should not be taken from field duplicates (FDs) or field blanks. FDs will be requested at a set frequency for each project (usually one per 10 samples). FDs should not be taken from MSs, MSDs, or field blanks. The MS and MSD samples listed on the COC should be spiked and analyzed by the laboratory.

A 100% QC will be performed on COCs received from the field crew. The field crew and/or lab will be notified if corrections need to be made to the COCs or lab login reports. Any corrections or modifications made will be noted in a Corrections-To-File Letter.

4.2.5 Sample and Document Tracking

The STS will be updated with sample collection and tracking information, and kept current throughout the data management process. All samples collected, resulting deliverables, and deliverable dates will be tracked throughout the data management process to ensure that the project schedule is met and subcontractor invoices are evaluated correctly.

All documentation acquired during the data management process, including Statements of Work (SOWs), Bids, COCs, Field Notes, Sample Tracking Sheets, Login Reports, Corrections-to-File Letters, FDETool QC tables, Post Load Reports, Invoices, and Communication Logs shall be compiled throughout the process to be stored in the appropriate Activity's Project Notebook.

4.2.6 Field Data

Once the field data and samples are collected, necessary field measurements, such as water levels and other data collected in the field should be entered into the FDETool. Any data entered into the FDETool must be exported into an excel file to facilitate a manual QC review of the data. The correction of any anomalies should be verified with the PM and PC. The information entered into the FDETool will be linked with related analytical data reported in the SNEDD within the SVMTool. Field data and laboratory analytical data are linked by sample ID and date/time. This allows verification analytical results for all samples have been received and reported by the laboratory.

4.3 Laboratory Analysis

Figure 5 shows the laboratory analysis process. Upon receipt of samples from the field, the laboratory will verify that the COC forms correctly identify and detail all samples submitted. Each COC form must be signed with the date and time of receipt by the laboratory. Samples will be logged in by the laboratory using information from the COC forms and the project instructions.

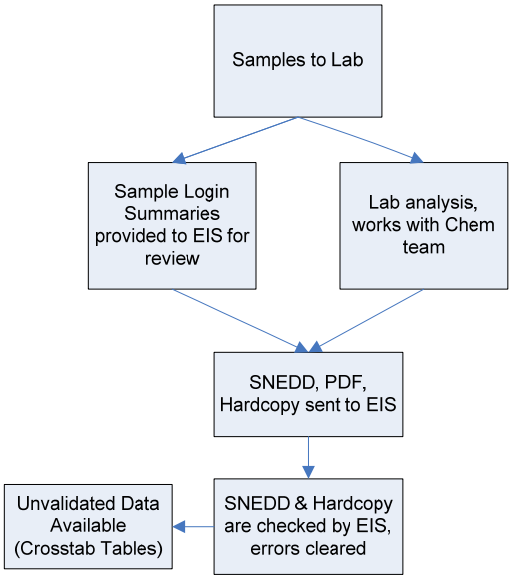


FIGURE 5
LABORATORY ANALYSIS

Samples will be analyzed as specified on the accompanying COC forms and in the Laboratory SOW. Generally, questions or noted inconsistencies identified by the laboratory should be addressed directly to the EIS. Login summaries detailing all samples and analyses received by the lab should be provided daily to the EIS for review. All discrepancies should be corrected to ensure that all samples are analyzed as per project instructions.

The SNEDD-QC-Tool is used to QC the laboratory's SNEDD. Before the laboratory analytical data is formatted into data tables or sent for validation, the laboratory SNEDD must be processed through CH2M Hill's SNEDD-QC-Tool Microsoft Access database application. The SNEDD-QC-Tool includes several automated diagnostic checks to verify format and content compliance with SNEDD specifications.

- The analytical laboratory may, at their discretion, utilize the tool to QC and correct any errors before transmitting the SNEDD to CH2M HILL. The laboratory will forward the checked SNEDD and a hard copy of the data to the EIS, who will manage the SNEDD verification process.
- Upon receipt at CH2M Hill, the EIS will check the SNEDD using the SNEDD-QC-Tool to verify correct format and content. If errors are found, the laboratory will be notified of the errors, and the SNEDD corrected.

The laboratory will attach the signed COCs to their hard copy data deliverables to officially relinquish control of the data back to the Environmental Contractor within the specified turnaround time. Data archiving forms will be generated and affixed to each laboratory report received per Sample Delivery Group (SDG) for cataloguing, tracking, and archiving purposes.

Hard copy data and SNEDDs will be reviewed to ensure that they are complete and acceptable as outlined in the Data QC Checklist. A 10% comparison between the hard copy and SNEDD content will be conducted to ensure consistency, resolve discrepancies, and document data error issues (for example, EDD re-submissions, turnaround time problems, hard copy incompleteness). All detected errors should be resolved with the laboratory.

These checks ensure the consistency and the validity of the SNEDD and hardcopy content before the data are reported in preliminary tables or sent for validation. The objective of using the SNEDD-QC-Tool is to ensure that the validation process is performed on consistently high-quality data and minimize the chance of finding data errors later in the validation process, which would require the laboratory to resend corrected data and start the validation process over again.

Preliminary raw and detects tables will be generated from data reported in the SNEDD by the Navy RD Formatting Tool – Unval/Val SNEDD. A separate table must be created for each matrix, and provided to the PM for review.

4.4 Data Validation

Once the preliminary data verification is complete, the PC is notified by the EIS that the data is available for validation. The PC will notify the data validator in advance of when to expect data and of any samples or analyses that should not be validated (i.e. grain size should not be validated). For internal data validation, the EIS will notify the PC of data availability, and provide the hardcopy data and a QC Association Table.

Upon receipt of data from CH2M HILL, data validation will be performed in accordance with the Data Validation SOW, UFP SAP, and any other documents required. Generally, questions or noted inconsistencies identified by the validator should be addressed directly to laboratory, with the PC notified of issues and resolutions identified.

4.4.1 External Data Validation

For external data validation, a copy of the SNEDD, hard copy data, and a QC Association Table will be provided to the data validator. The PC will coordinate the return of the data package to CH2M HILL for archiving with the data validator.

Data Validators will provide the following materials to the PC within the required turn around time:

- Hardcopy Data Validation Report
- Validated Version of the SNEDD (external validation)

Once returned to CH2M HILL, the SNEDD will be run through the SNEDD-QC-Tool, which includes automated diagnostic checks for validated data to verify format and content compliance with SNEDD validation specifications. The PC will review the validated data to ensure that they are complete and acceptable as outlined in the Data QC Checklist. A 100% QC check will be performed on the validated results to ensure that the hard copy data matches the SNEDD. All detected errors should be resolved with the data validator.

Data archiving forms will be generated and affixed to each Data Validation Report per SDG received for cataloguing, tracking, and archiving purposes.

Validated raw and detects tables will be generated from data reported in the validated SNEDD by the Navy RD Formatting Tool – Unval/Val SNEDD. A separate table must be created for each matrix, and provided to the PM for review.

4.4.2 Internal Data Validation

For internal data validation, a copy of the SNEDD, hard copy data, and a QC Association Table will be provided to the PC.

The PC will evaluate QC information, associated validation logic, and apply qualifiers to data in the SNEDD and on the laboratory Form Is when QC criteria are not achieved. Qualifier criteria will be based on the Quality Assurance Project Plan. A hardcopy data validation report will be generated. Data archiving forms will be generated and affixed to each Data Validation Report per SDG validated for cataloguing, tracking, and archiving purposes

Validated raw and detects tables will be generated from data reported in the validated SNEDD by the Navy RD Formatting Tool – Unval/Val SNEDD. A separate table must be created for each matrix, and provided to the PM for review.

4.4.3 Unvalidated Data Preload Check

Occasionally, unvalidated data will need to be loaded into the database. Although the data will not be validated, it will undergo a basic Preload Check by the PC to ensure laboratory compliance with project guidelines and determine results to be reported as the best result where multiple runs were conducted for a given sample/analysis. The PCL will provide input and oversight to ensure that data flags are applied correctly by the PC.

4.4.4 Senior Review

The PCL will verify that the final SNEDD and hardcopy data are complete and acceptable. Any identified discrepancies will be resolved with the assistance of the PC, EIS, laboratory, or validator as needed.

4.5 Data Preparation and Loading

Once the data are considered final and approved by the PCL, they are exported from the SNEDD to the project Data Warehouse. Field and laboratory data are merged into a format that is amenable to the warehouse. The backbone is a SQL-server-based data warehouse.

4.5.1 Data Preparation

As part of the normal process of loading data into the warehouse, data standardization tasks must be completed. A Database Specialist (DBS) will load data into the warehouse using the following three programs: SNEDD-QC-Tool, SVMTool and CH-IMPTool.

A final QC of the data reported in the SNEDD is conducted with the SNEDD-QC-Tool. Any identified discrepancies will be resolved with the assistance of the PCL, PC, or EIS as needed. SNEDDs that pass all of the QA/QC checks in the SNEDD-QC-Tool are then processed with the SVMTool.

The SVMTool links the field data contained in the FDETool to the analytical data contained in the SNEDD. A series of logical QC checks are run to ensure that all data links correctly minimum data requirements are met. The tool then merges the data into a format compatible with the data warehouse structure.

4.5.2 Data Loading

CH2M HILL Loading

The CH-IMPTool runs an additional series of QC checks and adds project-specific formatting, and loads the data into the warehouse. The following tasks need to be completed to load the data for project use:

- **Unit Standardization:** Analytical units and the associated results, reporting limits, and method detection limits will need to be converted to a consistent set of units as required by the project.
- **Resolve Reanalysis and Dilutions:** All samples that had an associated reanalysis or dilution run by the laboratory must have all of the excluded or rejected results marked as not the best result for reporting.
- **Resolve Analytical Overlap and Split Samples:** Analytical overlap occurs when a sample is analyzed by two or more methods that report the same analyte. To resolve any issues not previously resolved, the following logic is used to select the usable result:
  - If the overlapping results are all non-detections, the lowest non-detection result is selected.
  - If the overlapping results are all detected, the highest detected result is selected.
  - If the overlapping results consist of a mixture of detections and non-detections, the highest detected result is selected.

When data are loaded into the warehouse, an automated script will run to identify the “best” result when more than one analytical result exists.

NIRIS Loading

All Navy CLEAN and Joint Venture data must be loaded into NIRIS. Following the successful loading of data into the data warehouse, the DBS will use the FDETool and ALPTool to generate project NIRIS Electronic Data Deliverables (NEDD) files. Field-related NEDDs will be generated from the final version of the FDETool. The final version of the project SNEDD will be processed through the ALPTool to generate the analytical NEDD.

The DBS will use NIRIS's Data Checker Loader Tool to QC and submit the project NEDD files into NIRIS. The NIRIS Regional Database Manager (RDM) will load the data into NIRIS, and will work with the DBS to resolve any potential issue that may arise during loading. Following notification of successful data loading from the RDM, the DBS will query the data from NIRIS for review to ensure data integrity and accuracy.

4.5.3 Data Warehouse

The data warehouse is a Microsoft SQL Server 2005 relational database. This database, and all other "CH" tools used, has a data structure designed to achieve compliance with the Environmental Restoration Program Information Management System (ERPIMS) standard specified by Air Force Center for Engineering and the Environment (AFCEE). ERPIMS is an effective, comprehensive standard for environmental management.

The warehouse will use valid value tables when applying reference attributes to project data. Such reference data include the names of site objects and sampling locations, sampling matrix and method categories, analyte names, units. These reference tables are critical for maintaining the completeness and accuracy of data sets and are essential for accurate querying of the data.

Data are loaded and stored so that relationships among categories of data are enforced. For instance, all sampling records must be associated with a valid site object such as a planned sediment sampling location. The project repository database and collection, analysis, and reporting tools used in the DBMS are designed to enforce, for any project data record, entries in fields that refer to other types of data as required by the overall data model.

4.6 Data Reporting

Data reporting includes the following tasks:

- Retrieving data from the data warehouse for project deliverables, data visualization, or consumption by third parties
- Reviewing initial data and producing data queries and draft reports to dissect and disassemble the data
- Producing any requested client and regulatory agency data deliverables

Data for project deliverables, data visualization, or consumption by third parties will be retrieved from the warehouse, and will be equivalent to the real-time state of the project repository database. PMs and GIS Analysts (GAs) will work with the EIS and PCL for quality queries and data for reports.

4.6.1 Tables, Figures, and Diagrams

Once the data have been sufficiently analyzed, the list of requested data reports (tables, figures, diagrams) can be developed and finalized by the project team and submitted to the PCL and PM for review.

All requests for figures or graphics are to be directed to the GA assigned as the Point of Contact (POC) for that particular Navy installation. All requests for analytical data (crosstab tables, data dumps, third party deliverables etc) should be directed to the EIS assigned as the POC for that particular Navy installation. The EIS will generate a data deliverable from the data warehouse

or NIRIS (as needed) suitable for end use and will provide data support to the end user. All requests for data statistics and calculations should be directed to the Risk Assessor assigned to the project.

4.6.2 GIS

The Navy CLEAN program will utilize ESRI's suite of GIS software for the majority of GIS-related tasks. The GIS data model will consist of one or more geodatabases (GDBs) per installation. Each installation will maintain one common installation GDB, which will store the common infrastructure data such as buildings, roads, topography, hyrdography, utilities, etc. The common installation GDB should adhere, as much as possible, to the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE) data model. All project specific GDBs shall be developed and named for ease of interpretation by the GA.

All station location information for each installation will be pulled directly from the data warehouse and stored in the common installation GDB as a data table. The data warehouse must contain valid coordinate information for the locations to be displayed correctly. Valid coordinate information will be maintained in the data warehouse by the EIS, and updated as necessary by the DBS.

ESRI's ArcMap 9.3 (or the latest version available) will be utilized for spatially displaying the environmental data within maps and figures, as well as for spatial analysis. The GA will need to coordinate efforts with the EIS on all requests that require the display of environmental sample data on a map to ensure that the appropriate data is queried from the data warehouse and linked to the appropriate station location table within the GIS.

4.6.3 Site Information Management System

This is currently not being used on the Navy CLEAN and Joint Venture Programs.

SIMS is a tool for publishing data of sufficient quality from the project. However, the project data warehouse will remain the database of record for the project.

SIMS provides many standard report formats, all of which are used in conjunction with the Query Tool feature, to isolate and retrieve information. Users can generate and save their queries using a graphical point-and-click tool. Reports in a wide variety of formats also can be requested and produced.

4.6.4 Legacy Data

Legacy data are those collected from any contractor other than CH2M HILL and data collected by CH2M HILL that have not been managed in accordance with Navy CLEAN and Joint Venture Program requirements. Legacy data are commonly compiled from various electronic and hard copy sources including spreadsheets, databases, technical reports, and laboratory hard copy data reports. When working with legacy data, usability assessment must be completed for the project team to be able to use the data with confidence. In order to assess the data properly, the legacy data needs to be evaluated by skilled professionals that are familiar with the type of data being evaluated so that any errors identified in the data can be corrected when possible or qualified in a manner to reflect the limitations of the data's use.

The PM has overall responsibility for the selection for inclusion of legacy data into the data management process. The PDL and PCL will work with the PM to establish the data review

and import process, compile a comprehensive data inventory, and identify staff to facilitate data review.

The PDL and PCL will work with the EIS to determine the appropriate intermediary files and tools used to collect the data. The PDL and PCL will oversee the data review and flagging process and approve the data for upload into the Data Warehouse. The EIS is responsible for assembling the field and laboratory data in formats that facilitate data review, aid the PDL and PCL in overseeing the data review and flagging process, schedule, conversion of the data to the proper data warehouse format, and then loading the data into the Data Warehouse after approval by the PDL and PCL.

The GA, PDL, PCL, and PM have the primary responsibility for reviewing the data in their area of expertise and providing the PCL with data usability flags to be associated with each record.

SECTION 5

Project Closeout

The project completion/closeout phase includes the following:

- Archive hard copy and electronic documents
- Conduct project closeout meeting

5.1 Archive Procedures

A large variety of technical data will be generated during the field investigations. The EIS and PC will collect all hard copy and electronic data they are responsible for and verify that the incoming records are legible and in suitable condition for storage. Record storage will be performed in two stages:

- Storage during the project
- Permanent storage following project completion

During the project, CH2M HILL will store data hardcopy reports in CH2M HILL offices. Physical records will be secured in steel file cabinets or shelves, and labelled with the appropriate project identification. Electronic data will be maintained on CH2M HILL's corporate local area network servers.

Information generated from field activities will be documented on appropriate forms and will be maintained in the project file. These include COC records, field logbooks, well construction forms, boring logs, location sketches, and site photographs. In addition, notes from project meetings and telephone conversations will be filed.

Following project completion, both hard copy and electronic data deliverables will be archived. Team staff will provide all hard copies of laboratory and validation reports to the Data Closeout Coordinator to be prepped and shipped to Stone Mountain for archiving. Final laboratory SNEDDs and loading files will be provided to the PDL, to be archived on CH2M HILL's corporate local area network servers.

Any modifications made to the tools will be communicated to the project team via e-mail. As revisions are finalized, they will be distributed electronically to all users. After revision, it is the user's responsibility to conform to revised portions of the DMP.

5.2 Invoice Review and Approval

The EIS is responsible for tracking all data deliverables throughout the data management process to ensure that the project schedule is maintained, subcontractors comply with all required turn around times, and data provided are complete and acceptable. Following project completion, EISs are to review and provide comments on all laboratory and data validator invoices regarding data quality and schedule compliance prior to approval by the PM.

5.3 Project Closeout

At the end of each project, the PM will notify team staff of project closeout. The PM will coordinate and verify that all pertinent data has been archived. The PM may also review lessons learned, suggest process improvements, or revisions to the DMP and other project documentation as deemed necessary.

Appendix A
Environmental Data Management Work Process

Environmental Data Management Work Process

1.0 Project Planning & Setup	2.0 Sample Collection & Management	3.0 Lab Analysis	4.0 Data Validation	5.0 Data Management	6.0 Data Evaluation & Reporting
1.1 Project Setup	2.1 Sample Management	3.1 Sample Analysis	4.1 Internal Chemical Data Validation	5.1 CH2M HILL Data	6.1 Data Prep & Processing for Reporting
1.2 QAPP, SAP, DMP, DQOs Integration	2.2 Sample Collection	3.2 EDD Management	4.2 External Chemical Data Validation	5.2 Other Contractor & Legacy Data	6.2 Tabular Data Queries & Reports
1.3 Laboratory Setup	2.3 Sample Data Management	3.3 Hard Copy Management	4.3 Senior Review of Validated Data	5.3 Database Maintenance & Administration	6.3 Field Logs and Graphs
1.4 Database Setup					6.4 GIS Queries and Maps

Appendix B
Life of a Sample

A Sample's Life

Step-by-Step Outline of Navy CLEAN and JV Data Management Process, and Roles & Responsibilities

Step 1

Planning Phase

- Staffing Schedules
- Kickoff Meeting – Include the EIS & PC
- Project Instructions (PIs)
  - Sample Nomenclature provided in table
  - Reviewed by DMC (Chelsea Bennet) or Database Specialist

Step 2A

Sample Collection

- Daily collection and shipments of samples
- One COC/cooler; One FedEx slip/cooler
- Coordinate w/ EIS for tracking & Lab notification
- GPS conducted (if applicable)

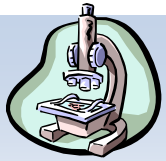
Step 2B

Sample Tracking

- EIS cross checks COC against PIs
- Also reviews lab confirmation sheets to verify all samples were received and in appropriate condition

Step 3

Lab Analysis



- Standard 28-day unless otherwise arranged
- EIS reviews data for accuracy and works with lab to resolve discrepancies
- EIS tracks schedule and keeps PM informed
- EIS inputs STSP information from Log Books
- EIS can generate Unvalidated Raw and Detects Data Tables

Step 4

Data Validation

- PC reviews all data for accuracy against the PIs
- PC sends data from lab to Data Validator
- Delays may occur if there is missing data or data is late from the lab\
- EIS can generate Validated Raw and Detects Data Tables

Step 5

Data Load

- PCL sends data to Database Specialist to be loaded into the Data Warehouse (DW)
- (Sometimes this involves assistance from PM, FTL, PC, and/or EIS)

Step 6

Quality Assurance/ Quality Control

- EIS & PC are notified that data is loaded
- EIS verifies info loaded is correct (Sample, Station, Analyses, Result)
- EIS then helps decide whether info needs to be updated or not
- File and archive all Lab and DV deliverables

Step 7

Report Generation

- Raw, Detects, Exceedance Reports
- Data Requests
- Exceedance Reports (criteria needed prior to this step and selected by PM)
- Human Health Risk Assessment
- Eco Risk Assessment

End of our Sample's Life?

- Data may be used in reports, posted on web, put into GIS, etc
- In that regard, a sample's life doesn't really ever end!
- Hopefully our sample had no exceedances and everyone is happy.

Appendix C
Standard Operating Procedures

Checklist – Archive and NIRIS Load Prep

Checklist – Data QC

Checklist - EIS Project Start-up Questions

Checklist - Generating RDE Tables

Checklist - Historic Data Cleanup

Checklist - SNEDD DM Process

Roles – Data Management Coordinator

Roles – EIS

Roles – Project Manager

Template – STS & QC Association Table

SOP-114 - CHIMPTool

SOP-126 - XTab Reports Tool

SOP - Access to NIRIS

SOP - Cherry Point Exceedance Formatting Wizard

SOP – CLEAN SNEDD Loading with CHIMPTool

SOP - Corrections to File

SOP - Data Archiving Procedures

SOP - Data Shipping

SOP – FDET

SOP – FDET Setup

SOP – NIRIS Importer Validator Tool

SOP – SVMTool

SOP – Valid Value Setup

Appendix D
Electronic Data Deliverable Specifications

CH2M HILL SNEDD Format			
Field Name	**Field Format**	**REQ**	**Field Description**
Contract_ID	A13	R	Contract ID assigned by Division Contracting Office, not including dashes. Found on Statement of Work. (e.g. D459559365800)
DO_CTO_Number	A4	R	CTO or TO # assigned by Navy. (e.g. CTO-12 = 0012, TO-54 = TO54)
Phase	A8	NR	Task Phase, SubTask Number or Annual Quarter. (e.g. QTR1)
Installation_ID	A20*	R	Unique identifier for installation. (e.g. WHIDBEY)
Sample_Name	A50	R	CH2M HILL Sample ID (from Chain Of Custody).
CH2M_Code	A4*	R	CH2M HILL Preparation Method Code (e.g. NONS)
Analysis_Group	A9*	R	The CH2M HILL code for the analysis performed on the sample.
Analytical_Method	A20*	R	Analytical Method used to analyze sample fraction. (e.g. 6010)
PRC_Code	A15*	R	NIRIS code for the analytical method category (e.g. PCHAR)
Lab_Code	A10*	R	CH2M HILL Code assigned to the laboratory (e.g. COMP)
Lab_Name	A50*	R	The name of the laboratory that conducted the analysis, in all CAPS.
Leachate_Method	A16*	RA	Code for the leachate method used on sample. (e.g. SW1310)
Sample_Basis	A16*	R	Sample basis of analysis; wet weight, dry weight etc. (e.g. DRY)
Extraction_Method	A16*	RA	Code for the extraction method used on sample. (e.g. FLTRES)
Result_Type	A16*	R	Type of results; dilution, reanalysis etc. (e.g. 000)
Lab_QC_Type	A15*	R	Code for Laboratory Sample (MS, MSD, LBLK, LCS)
Sample_Medium	A16*	R	Sample medium reported by the laboratory. (e.g. L)
QC_Level	A16*	R	QC Level of data package : EPA levels I to IV. (e.g. 3)
DateTime_Collected	MM/DD/YYYY 00:00	R	Date and time sample was collected. Use 24 hour clock. (e.g. 02/13/2007 15:34)
Date_Received	MM/DD/YYYY	R	The date the sample was received in the lab (in 10 characters). (e.g. 03/24/2007)
Leachate_Date	YYYYMMDD	RA	Date the sample was leached. Req'd if sample was leached and/or Leachate Method provided. (e.g. March 12, 2007 = 20070312)
Leachate_Time	HH:MM:SS	RA	Time the sample was leached. Use 24 hour clock, with 8 characters. (e.g. 14:30:05). Req'd if sample was leached and/or Leachate Method provided.
Extraction_Date	YYYYMMDD	RA	Date that the lab extracted the sample. Req'd if Extraction Method provided.
Extraction_Time	HH:MM:SS	RA	Time of day lab extracted the sample. Use 24 hour clock, with 8 characters. Req'd if Extraction Method provided. (e.g. 02:15:00)
Analysis_Date	YYYYMMDD	R	Date that the lab performed the analysis.
Analysis_Time	HH:MM:SS	R	Time of day that the lab extracted the sample. Use 24 hour clock, with 8 characters.
Lab_Sample_ID	A20	R	Unique ID assigned to the sample by the laboratory.

CH2M HILL SNEDD Format			
Field Name	**Field Format**	**REQ**	**Field Description**
Dilution	N10,2	R	Dilution factor used. Default value is 1 (e.g. 10)
Run_Number	N4	R	Number distinguishing multiple or repeat analyses by the same method (incl. RA, RE, DL, etc). Must be equal to or greater than 1.
Percent_Moisture	N6,3	RA	Percent moisture of the sample. (e.g. 20)
Percent_Lipid	N6,3	RA	Percent lipid of the sample.
Chem_Name	A55*	R	The name of the compound being analyzed.
Analyte_ID	A20*	R	Analyte ID (CAS Number) assigned to the analyte. (e.g. 7440-47-3)
Analyte_Value	N18,7	R	Leave Blank for Validator to enter the final analyte concentration.
Original_Analyte_Value	N18,7	R	Analyte concentration value originally generated by the Laboratory.
Result_Units	A16*	R	Unit of measure for the analyte value. (e.g. UG_L)
Lab_Qualifier	A16*	RA	Lab data qualifier. Values will not be rejected if not in domain table.
Validator_Qualifier	A16*	RA	Leave blank for Validator. Values will not be rejected if not in domain table.
GC_Column_Type	A16*	RA	Data code for the type of GC column used in an analysis.
Analysis_Result_Type	A4*	R	Type of analysis performed (allowed: SURR or TRG).
Result_Narrative	A120	RA	Additional information or comments associated with the result.
QC_Control_Limit_Code	A16*	RA	Type of quality control limit. Req'd if QC criteria and upper/lower accuracy included. (e.g. CLPA)
QC_Accuracy_Upper	N6,3	RA	Upper QC limit of % recovery as measured for a known target analyte spiked into a QC sample. (e.g. 25.45)
QC_Accuracy_Lower	N6,3	RA	Lower QC limit of % recovery as measured for a known target analyte spiked into a QC sample. (e.g. 10.15)
Control_Limit_Date	YYYYMMDD	RA	Date a control limit is established.
QC_Narrative	A120	RA	Leave blank for Validator. Enter DV_Qual_Code.
MDL	N18,7	RA	Method Detection Limit
Detection_Limit	N18,7	RA	Reported Detection Limit
SDG	A50	R	Lab code for a group of samples in a data deliverable package.
Analysis_Batch	A20	R	Laboratory code for a batch of analyses analyzed together.
Validator_Name	A50*	R	Leave Blank. Name of Validator in all CAPS. (e.g. CONTRACTOR INC.)
Val_Date	YYYYMMDD	RA	Populated by Validator/Reviewer. Validation/Review QC date.

Attachment 4
DoD ELAP Accreditation Letter – Analytical Laboratories

The American Association for Laboratory Accreditation

World Class Accreditation

Accredited DoD ELAP Laboratory

A2LA has accredited

ENVIRONMENTAL CONSERVATION LABORATORIES - JACKSONVILLE

Jacksonville, FL

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (QSM v4.1); accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION
CORPORATE SEAL 1978
DISTRICT OF COLUMBIA
A2LA

Presented this 29th day of March 2010.

President & CEO
For the Accreditation Council
Certificate Number 3000.02
Valid to April 30, 2012

For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

SCOPE OF ACCREDITATION TO ISO/IEC 17025-2005

ENVIRONMENTAL CONSERVATION LABORATORIES – JACKSONVILLE
4810 Executive Park Court, Suite 211
Jacksonville, FL 32216
Dr. Mark Inman Phone: 904 296 3007
Email address: minman@encolabs.com

ENVIRONMENTAL

Valid To: April 30, 2012 Certificate Number: 3000.02

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.1)) accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
Isopropyl alcohol (2-Propanol)	EPA 8015C	----------	ENCO VGCMS-07
4-Ethyltoluene	----------	----------	ENCO VGCMS-07
Cyclohexane	EPA 8260B	EPA 8260B	ENCO VGCMS-07
1,1,1-Trichloroethane	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,1,2,2-Tetrachloroethane	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,1,2-Trichloro-1,2,2-trifluoroethane	EPA 8260B	EPA 8260B	EPA TO-14A
1,1,2-Trichloroethane	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,1-Dichloroethane	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,1-Dichloroethylene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,2-Dichloro-1,1,2,2-tetrafluoroethane	----------	----------	EPA TO-14A
1,3-Butadiene	----------	----------	EPA TO-15
1,4-Dioxane	EPA 8260B	EPA 8260B	EPA TO-15
2,2,4-Trimethylpentane	NA	----------	EPA TO-15
Benzyl chloride	----------	----------	EPA TO-15
n-Hexane	----------	----------	EPA TO-15
2-Hydroxy isobutyric acid	ENCO VGC-13	----------	----------
Acetic acid	ENCO VGC-13	----------	----------
Butyric acid (Butanoic acid)	ENCO VGC-13	----------	----------
Hexanoic acid	ENCO VGC-13	----------	----------

5301 Buckeystown Pike, Suite 350 | Frederick, Maryland 21704-8373 | Phone: 301 644 3248 | Fax: 301 662 2974 | www.A2LA.org

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
Isohexanoic acid (4-methyl-pentanoic acid)	ENCO VGC-13	----------	----------
Isopentanoic acid (3-methyl-butanoic acid)	ENCO VGC-13	----------	----------
Lactic acid	ENCO VGC-13	----------	----------
Pentanoic acid	ENCO VGC-13	----------	----------
Propionic acid (Propanoic acid)	ENCO VGC-13	----------	----------
Pyruvic acid	ENCO VGC-13	----------	----------
Propylene glycol	ENCO VGC-18	----------	----------
Ethyl acetate	EPA 8015C	----------	ENCO VGCMS-07
Ethylene glycol	EPA 8015C	----------	----------
Gasoline range organics (GRO)	EPA 8015C	EPA 8015C	----------
Isobutyl alcohol (2-Methyl-1-propanol)	EPA 8015C, 8260B	EPA 8260B	----------
Methanol	EPA 8015C	----------	----------
n-Butyl alcohol	EPA 8015C	----------	----------
n-Propanol	EPA 8015C	----------	----------
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504, 504.1, 8011, 8260	EPA 8260B	----------
1,2-Dibromoethane (EDB, Ethylene dibromide)	EPA 504, 504.1, 8011, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,2-Dichlorobenzene	EPA 624, 8260B, 8270D	EPA 8260B, 8270D	EPA TO-14A, EPA TO-15
1,2-Dichloroethane	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,2-Dichloropropane	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,3-Dichlorobenzene	EPA 624, 8260B, 8270D	EPA 8260B, 8270D	EPA TO-14A, EPA TO-15
1,4-Dichlorobenzene	EPA 624, 8260B, 8270D	EPA 8260B, 8270D	EPA TO-14A, EPA TO-15
2-Chloroethyl vinyl ether	EPA 624, 8260B	EPA 8260B	----------
Acrolein (Propenal)	EPA 624, 8260B	EPA 8260B	----------
Acrylonitrile	EPA 624, 8260B	EPA 8260B	----------
Benzene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Bromodichloromethane	EPA 624, 8260B	EPA 8260B	ENCO VGCMS-07
Bromoform	EPA 624, 8260B	EPA 8260B	EPA TO-15
Carbon tetrachloride	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Chlorobenzene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Chloroethane	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Chloroform	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
cis-1,3-Dichloropropene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Dibromochloromethane	EPA 624, 8260B	EPA 8260B	ENCO VGCMS-07
Ethylbenzene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Methyl bromide (Bromomethane)	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Methyl chloride (Chloromethane)	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Methylene chloride	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Tetrachloroethylene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Toluene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
trans-1,2-Dichloroethylene	EPA 624, 8260B	EPA 8260B	EPA TO-15
trans-1,3-Dichloropropylene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Trichloroethene	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Trichlorofluoromethane	EPA 624, 8260B	EPA 8260B	EPA-TO-14A

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
Vinyl chloride	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Xylene (total)	EPA 624, 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
1,1,1,2-Tetrachloroethane	EPA 8260B	EPA 8260B	----------
1,1-Dichloropropene	EPA 8260B	EPA 8260B	----------
1,2,3-Trichlorobenzene	EPA 8260B	EPA 8260B	----------
1,2,3-Trichloropropane	EPA 8260B	EPA 8260B	----------
1,2,4-Trichlorobenzene	EPA 625, 8260B, 8270D	EPA 8260B, 8270D	EPA TO-14A, EPA TO-15
1,2,4-Trimethylbenzene	EPA 8260B	EPA 8260B	EPA TO-14A
1,3,5-Trimethylbenzene	EPA 8260B	EPA 8260B	EPA TO-14A
1,3-Dichloropropane	EPA 8260B	EPA 8260B	----------
2,2-Dichloropropane	EPA 8260B	EPA 8260B	----------
2-Butanone (Methyl ethyl ketone,MEK)	EPA 8015, 8260B	EPA 8260B	EPA TO-15
2-Chlorotoluene	EPA 8260B	EPA 8260B	NA
2-Hexanone	EPA 8260B	EPA 8260B	ENCO VGCMS-07
4-Chlorotoluene	EPA 8260B	EPA 8260B	----------
4-Methyl-2-pentanone (MIBK)	EPA 8015C , 8260B	EPA 8260B	EPA TO-15
Acetone	EPA 8260B	EPA 8260B	----------
Acetonitrile	EPA 8260B	EPA 8260B	----------
Allyl chloride (3-Chloropropene)	EPA 8260B	EPA 8260B	EPA TO-15
Bromobenzene	EPA 8260B	EPA 8260B	----------
Bromochloromethane	EPA 8260B	EPA 8260B	----------
Carbon disulfide	EPA 8260B	EPA 8260B	EPA TO-15
Chloroprene	EPA 8260B	EPA 8260B	----------
cis-1,2-Dichloroethylene	EPA 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
Dibromomethane	EPA 8260B	EPA 8260B	----------
Dichlorodifluoromethane	EPA 8260B	EPA 8260B	EPA TO-14A
Ethanol	EPA 8015, 8260B	EPA 8260B	----------
Hexachlorobutadiene	EPA 625, 8260B, 8270D	EPA 8260, 8270	EPA TO-14A, EPA TO-15
Isopropylbenzene	EPA 8260B	EPA 8260B	----------
Methacrylonitrile	EPA 8260B	EPA 8260B	----------
Methyl methacrylate	EPA 8260B	EPA 8260B	----------
Methyl tert-butyl ether (MTBE)	EPA 8260B	EPA 8260B	EPA TO-15
m-Xylene	EPA 8260B	EPA 8260B	----------
Naphthalene	EPA 625, 8260B, 8270D, 8270D PAHSIM	EPA 8260B, 8270D, 8270D PAHSIM	----------
n-Butyl benzene	EPA 8260B	EPA 8260B	----------
n-Propyl benzene	EPA 8260B	EPA 8260B	----------
o-Xylene	EPA 8260B	EPA 8260B	----------
p-Isopropyltoluene	EPA 8260B	EPA 8260B	----------
Propionitrile (Ethyl cyanide)	EPA 8260B	EPA 8260B	----------
p-Xylene	EPA 8260B	EPA 8260B	----------
sec-Butylbenzene	EPA 8260B	EPA 8260B	----------
Styrene	EPA 8260B	EPA 8260B	EPA TO-14A, EPA TO-15
tert-Butylbenzene	EPA 8260B	EPA 8260B	----------
trans-1,4-Dichloro-2-butene	EPA 8260B	EPA 8260B	----------
Vinyl acetate	EPA 8260B	EPA 8260B	EPA TO-15
4,4'-DDD	EPA 608, 8081B	EPA 8081B	----------
4,4'-DDE	EPA 608, 8081B	EPA 8081B	----------

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
4,4'-DDT	EPA 608, 8081B	EPA 8081B	----------
Aldrin	EPA 608, 8081B	EPA 8081B	----------
alpha-BHC (alpha-Hexachlorocyclohexane)	EPA 608, 8081B	EPA 8081B	----------
Aroclor-1016(PCB-1016)	EPA 608, 8082A	EPA 8082A	----------
Aroclor-1221(PCB-1221)	EPA 608, 8082A	EPA 8082A	----------
Aroclor-1232(PCB-1232)	EPA 608, 8082A	EPA 8082A	----------
Aroclor-1242(PCB-1242)	EPA 608, 8082A	EPA 8082A	----------
Aroclor-1248(PCB-1248)	EPA 608, 8082A	EPA 8082A	----------
Aroclor-1254(PCB-1254)	EPA 608, 8082A	EPA 8082A	----------
Aroclor-1260(PCB-1260)	EPA 608, 8082A	EPA 8082A	----------
beta-BHC (beta-Hexachlorocyclohexane)	EPA 608, 8081B	EPA 8081B	----------
Chlordane(tech.)	EPA 608, 8081B	EPA 8081B	----------
delta-BHC	EPA 608, 8081B	EPA 8081B	----------
Dieldrin	EPA 608, 8081B	EPA 8081B	----------
Endosulfan I	EPA 608, 8081B	EPA 8081B	----------
Endosulfan II	EPA 608, 8081B	EPA 8081B	----------
Endosulfan sulfate	EPA 608, 8081B	EPA 8081B	----------
Endrin	EPA 608, 8081B	EPA 8081B	----------
Endrin aldehyde	EPA 608, 8081B	EPA 8081B	----------
gamma-BHC (Lindane,gamma-Hexachlorocyclohexane)	EPA 608, 8081B	EPA 8081B	----------
Heptachlor	EPA 608, 8081B	EPA 8081B	----------
Heptachlor epoxide	EPA 608, 8081B	EPA 8081B	----------
Toxaphene (Chlorinated camphene)	EPA 608, 8081B	EPA 8081B	----------
alpha-Chlordane	EPA 8081B	EPA 8081B	----------
Endrin ketone	EPA 8081B	EPA 8081B	----------
gamma-Chlordane	EPA 8081B	EPA 8081B	----------
Isodrin	EPA 8081B, 8270D	EPA 8081B, 8270D	----------
Methoxychlor	EPA 8081B	EPA 8081B	----------
Mirex	EPA 8081B	EPA 8081B	----------
Kepone	EPA 8270D	EPA 8270D	----------
o,o,o-Triethylphosphorothioate	EPA 8270D	EPA 8270D	----------
Parathion,ethyl	EPA 8270D	EPA 8270D	----------
Phorate	EPA 8270D	EPA 8270D	----------
Sulfotepp	EPA 8270D	EPA 8270D	----------
Thionazin (Zinophos)	EPA 8270D	EPA 8270D	----------
Dalapon	EPA 615, 8151A	EPA 8151A	----------
3,5-DCBA	EPA 615, 8151A	EPA 8151A	----------
4-Nitrophenol	EPA 615, 625, 8151A, 8270D	EPA 8270D, 8151A	----------
Dicamba	EPA 615, 8151A	EPA 8151A	----------
MCPP	EPA 615, 8151A	EPA 8151A	----------
MCPA	EPA 615, 8151A	EPA 8151A	----------
Dichlorprop	EPA 615, 8151A	EPA 8151A	----------
2,4-D	EPA 615, 8151A	EPA 8151A	----------
Pentachlorophenol	EPA 615, 625, 8151A, 8270D	EPA 8151A, 8270D	----------
2,4,5-TP (Silvex)	EPA 615, 8151A	EPA 8151A	----------
Chloramben	EPA 615, 8151A	EPA 8151A	----------

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
2,4,5-T	EPA 615, 8151A	EPA 8151A	----------
2,4-DB	EPA 615, 8151A	EPA 8151A	----------
Bentazon	EPA 615, 8151A	EPA 8151A	----------
Picloram	EPA 615, 8151A	EPA 8151A	----------
Dinoseb	EPA 615, 625, 8151A, 8270D	EPA 8151A, 8270D	----------
Dacthal	EPA 615, EPA 8151A	EPA 8151A	----------
Acifluorfen	EPA 615, EPA 8151A	EPA 8151A	----------
2,4-DCAA	EPA 615, EPA 8151A	EPA 8151A	----------
Total coliforms	SM 9222B	----------	----------
Fecal coliforms	SM 9222D	----------	----------
Aluminum	EPA 200.7, 6010C	EPA 6010C	----------
Antimony	EPA 200.7, 6010C	EPA 6010C	----------
Arsenic	EPA 200.7, 6010C	EPA 6010C	----------
Barium	EPA 200.7, 6010C	EPA 6010C	----------
Beryllium	EPA 200.7, 6010C	EPA 6010C	----------
Boron	EPA 200.7, 6010C	EPA 6010C	----------
Cadmium	EPA 200.7, 6010C	EPA 6010C	----------
Calcium	EPA 200.7, 6010C	EPA 6010C	----------
Chromium	EPA 200.7, 6010C	EPA 6010C	----------
Cobalt	EPA 200.7, 6010C	EPA 6010C	----------
Copper	EPA 200.7, 6010C	EPA 6010C	----------
Hardness (calc.)	EPA 200.7, SM2340B	----------	----------
Iron	EPA 200.7, 6010C, SM 18 3500-Fe D	EPA 6010C	----------
Lead	EPA 200.7, 6010C	EPA 6010C	----------
Lithium	EPA 200.7, 6010C	EPA 6010C	----------
Magnesium	EPA 200.7, 6010C	EPA 6010C	----------
Manganese	EPA 200.7, 6010C	EPA 6010C	----------
Molybdenum	EPA 200.7, 6010C	EPA 6010C	----------
Nickel	EPA 200.7, 6010C	EPA 6010C	----------
Potassium	EPA 200.7, 6010C	EPA 6010C	----------
Selenium	EPA 200.7, 6010C	EPA 6010C	----------
Silver	EPA 200.7, 6010C	EPA 6010C	----------
Sodium	EPA 200.7, 6010C	EPA 6010C	----------
Strontium	EPA 200.7, 6010C	EPA 6010C	----------
Thallium	EPA 200.7, 6010C	EPA 6010C	----------
Tin	EPA 200.7, 6010C	EPA 6010C	----------
Titanium	EPA 200.7, 6010C	EPA 6010C	----------
Vanadium	EPA 200.7, 6010C	EPA 6010C	----------
Zinc	EPA 200.7, 6010C	EPA 6010C	----------
Mercury	EPA 245.1, 7470	EPA 7471	----------
Sulfate	ASTM D516-90	----------	----------
Ignitability	EPA 1010	EPA 1010, EPA 1030	----------
Conductivity	EPA 120.1, SM 18 2510B	----------	----------
Oil & Grease (HEM)	EPA 1664A	EPA 9071B	----------
Total Petroleum Hydrocarbons (TPH) (HEM-SGT)	EPA 1664A	----------	----------
Turbidity	EPA 180.1, SM 18 2130B	----------	----------
Orthophosphate as P	EPA 365.3	----------	----------
Color	SM 2120B	----------	----------
Alkalinity as CaC03	SM 2320B	----------	----------

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
Hardness	SM 2340C	----------	----------
Residue-nonfilterable (TSS)	SM 2540D	----------	----------
Residue-total	SM 2540B	----------	----------
Residue-filterable (TDS)	SM 2540C	----------	----------
Chromium VI	SM 3500-Cr D(18th/19th Ed.)/UV-VIS	----------	----------
Chloride	SM 4500-Cl C	----------	----------
Total residual chlorine	SM 4500-Cl G	----------	----------
pH	SM 18 4500-H+-B, EPA 9040	EPA 9040, 9045	----------
Nitrite	SM 4500-NO_2 B	----------	----------
Biochemical oxygen demand	SM 5210B	----------	----------
Carbonaceous BOD(CBOD)	SM 5210B	----------	----------
Chemical oxygen demand	SM 5220D, EPA 410.4	----------	----------
Total Organic Carbon	SM 18 5310B, EPA 9060	----------	----------
Total Petroleum Hydrocarbons (TPH)	FL-PRO	FL-PRO	----------
Carbon dioxide	RSK-175	----------	----------
Ethane	RSK-175	----------	----------
Ethylene	RSK-175	----------	----------
Methane	RSK-175	----------	----------
2,4,6-Trichlorophenol	EPA 625, 8270D	EPA 8270D	----------
2,4-Dichlorophenol	EPA 625, 8270D	EPA 8270D	----------
2,4-Dimethylphenol	EPA 625, 8270D	EPA 8270D	----------
2,4-Dinitrophenol	EPA 625, 8270D	EPA 8270D	----------
2,4-Dinitrotoluene (2,4-DNT)	EPA 625, 8270D	EPA 8270D	----------
2,6-Dinitrotoluene (2,6-DNT)	EPA 625, 8270D	EPA 8270D	----------
2-Chloronaphthalene	EPA 625, 8270D	EPA 8270D	----------
2-Chlorophenol	EPA 625, 8270D	EPA 8270D	----------
2-Methyl-4,6-dinitrophenol	EPA 625, 8270D	EPA 8270D	----------
2-Nitrophenol	EPA 625, 8270D	EPA 8270D	----------
3,3'-Dichlorobenzidine	EPA 625, 8270D	EPA 8270D	----------
4-Bromophenyl phenylether	EPA 625, 8270D	EPA 8270D	----------
4-Chloro-3-methylphenol	EPA 625, 8270D	EPA 8270D	----------
4-Chlorophenyl phenylether	EPA 625, 8270D	EPA 8270D	----------
Acenaphthene	EPA 625, 8270D	EPA 8270D	----------
Acenaphthylene	EPA 625, 8270D	EPA 8270D	----------
Aniline	EPA 625, 8270D	EPA 8270D	----------
Anthracene	EPA 625, 8270D	EPA 8270D	----------
Benzidine	EPA 625, 8270D	EPA 8270D	----------
Benzo(a)anthracene	EPA 625, 8270D	EPA 8270D	----------
Benzo(a)pyrene	EPA 625, 8270D	EPA 8270D	----------
Benzo(b)fluoranthene	EPA 625, 8270D	EPA 8270D	----------
Benzo(g,h,i)perylene	EPA 625, 8270D	EPA 8270D	----------
Benzo(k)fluoranthene	EPA 625, 8270D	EPA 8270D	----------
bis(2-Chloroethoxy)methane	EPA 625, 8270D	EPA 8270D	----------
bis(2-Chloroethyl) ether	EPA 625, 8270D	EPA 8270D	----------

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
bis(2-Chloroisopropyl) ether (2,2'-Oxybis(1-chloropropane)	EPA 625, 8270D	EPA 8270D	----------
bis(2-Ethylhexyl) phthalate(DEHP)	EPA 625, 8270D	EPA 8270D	----------
Butylbenzylphthalate	EPA 625, 8270D	EPA 8270D	----------
Chrysene	EPA 625, 8270D	EPA 8270D	----------
Dibenzo(a,h)anthracene	EPA 625, 8270D	EPA 8270D	----------
Diethyl phthalate	EPA 625, 8270D	EPA 8270D	----------
Dimethyl phthalate	EPA 625, 8270D	EPA 8270D	----------
Di-n-butyl phthalate	EPA 625, 8270D	EPA 8270D	----------
Di-n-octyl phthalate	EPA 625, 8270D	EPA 8270D	----------
Fluoranthene	EPA 625, 8270D	EPA 8270D	----------
Fluorene	EPA 625, 8270D	EPA 8270D	----------
Hexachlorobenzene	EPA 625, 8270D	EPA 8270D	----------
Hexachlorocyclopentadiene	EPA 625, 8270D	EPA 8270D	----------
Hexachloroethane	EPA 625, 8270D	EPA 8270D	----------
Indeno(1,2,3-cd)pyrene	EPA 625, 8270D	EPA 8270D	----------
Isophorone	EPA 625, 8270D	EPA 8270D	----------
Nitrobenzene	EPA 625, 8270D	EPA 8270D	----------
n-Nitrosodimethylamine	EPA 625, 8270D	EPA 8270D	----------
n-Nitrosodi-n-propylamine	EPA 625, 8270D	EPA 8270D	----------
n-Nitrosodiphenylamine	EPA 625, 8270D	EPA 8270D	----------
Phenanthrene	EPA 625, 8270D	EPA 8270D	----------
Phenol	EPA 625, 8270D	EPA 8270D	----------
Pyrene	EPA 625, 8270D	EPA 8270D	----------
Pyridine	EPA 625, 8270D	EPA 8270D	----------
1,1-Biphenyl	EPA 8270D	EPA 8270D	----------
1,2,4,5-Tetrachlorobenzene	EPA 8270D	EPA 8270D	----------
1,2-Diphenylhydrazine	EPA 8270D	EPA 8270D	----------
1,3,5-Trinitrobenzene (1,3,5-TNB)	EPA 8270D	EPA 8270D	----------
1,3-Dinitrobenzene (1,3-DNB)	EPA 8270D	EPA 8270D	----------
1,4-Naphthoquinone	EPA 8270D	EPA 8270D	----------
1,4-Phenylenediamine	EPA 8270D	EPA 8270D	----------
1-Methylnaphthalene	EPA 8270D	EPA 8270D	----------
1-Naphthylamine	EPA 8270D	EPA 8270D	----------
2,3,4,6-Tetrachlorophenol	EPA 8270D	EPA 8270D	----------
2,4,5-Trichlorophenol	EPA 8270D	EPA 8270D	----------
2,6-Dichlorophenol	EPA 8270D	EPA 8270D	----------
2-Acetylaminofluorene	EPA 8270D	EPA 8270D	----------
2-Methylnaphthalene	EPA 8270D	EPA 8270D	----------
2-Methylphenol (o-Cresol)	EPA 8270D	EPA 8270D	----------
2-Naphthylamine	EPA 8270D	EPA 8270D	----------
2-Nitroaniline	EPA 8270D	EPA 8270D	----------
2-Picoline (2-Methylpyridine)	EPA 8270D	EPA 8270D	----------
3,3'-Dimethylbenzidine	EPA 8270D	EPA 8270D	----------
3-Methylcholanthrene	EPA 8270D	EPA 8270D	----------
3-Methylphenol (m-Cresol)	EPA 8270D	EPA 8270D	----------
3-Nitroaniline	EPA 8270D	EPA 8270D	----------

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
4-Aminobiphenyl	EPA 8270D	EPA 8270D	----------
4-Chloroaniline	EPA 8270D	EPA 8270D	----------
4-Dimethyl aminoazobenzene	EPA 8270D	EPA 8270D	----------
4-Methylphenol (p-Cresol)	EPA 8270D	EPA 8270D	----------
4-Nitroaniline	EPA 8270D	EPA 8270D	----------
4-Nitroquinoline-n-oxide	EPA 8270D	EPA 8270D	----------
5-Nitro-o-toluidine	EPA 8270D	EPA 8270D	----------
7,12-Dimethylbenz(a)anthracene	EPA 8270D	EPA 8270D	----------
a-a-Dimethylphenethylamine	EPA 8270D	EPA 8270D	----------
Acetophenone	EPA 8270D	EPA 8270D	----------
Aramite	EPA 8270D	EPA 8270D	----------
Atrazine	EPA 8270D	EPA 8270D	----------
Benzaldehyde	EPA 8270D	EPA 8270D	----------
Benzoic acid	EPA 8270D	EPA 8270D	----------
Benzyl alcohol	EPA 8270D	EPA 8270D	----------
Caprolactam	EPA 8270D	EPA 8270D	----------
Carbazole	EPA 8270D	EPA 8270D	----------
Chlorobenzilate	EPA 8270D	EPA 8270D	----------
Cresol, Total	EPA 8270D	EPA 8270D	----------
Diallate	EPA 8270D	EPA 8270D	----------
Dibenzo(a,h)pyrene	EPA 8270D	EPA 8270D	----------
Dibenzofuran	EPA 8270D	EPA 8270D	----------
Dimethoate	EPA 8270D	EPA 8270D	----------
Diphenylamine	EPA 8270D	EPA 8270D	----------
Disulfoton	EPA 8270D	EPA 8270D	----------
DPH (as Azobenzene)	EPA 8270D	EPA 8270D	----------
Ethyl methanesulfonate	EPA 8270D	EPA 8270D	----------
Famphur	EPA 8270D	EPA 8270D	----------
Hexachlorophene	EPA 8270D	EPA 8270D	----------
Hexachloropropene	EPA 8270D	EPA 8270D	----------
Isosafrole	EPA 8270D	EPA 8270D	----------
Methapyrilene	EPA 8270D	EPA 8270D	----------
Methyl methane sulfonate	EPA 8270D	EPA 8270D	----------
Methyl parathion (Parathion,methyl)	EPA 8270D	EPA 8270D	----------
Nitroquinoline-1-oxide	EPA 8270D	EPA 8270D	----------
n-Nitrosodiethylamine	EPA 8270D	EPA 8270D	----------
n-Nitroso-di-n-butylamine	EPA 8270D	EPA 8270D	----------
n-Nitrosomethylethylamine	EPA 8270D	EPA 8270D	----------
n-Nitrosomorpholine	EPA 8270D	EPA 8270D	----------
n-Nitrosopiperidine	EPA 8270D	EPA 8270D	----------
n-Nitrosopyrrolidine	EPA 8270D	EPA 8270D	----------
o-Toluidine	EPA 8270D	EPA 8270D	----------
Pentachlorobenzene	EPA 8270D	EPA 8270D	----------
Pentachloroethane	EPA 8270D	EPA 8270D	----------
Pentachloronitrobenzene	EPA 8270D	EPA 8270D	----------
Phenacetin	EPA 8270D	EPA 8270D	----------
Pronamide (Kerb)	EPA 8270D	EPA 8270D	----------
Safrole	EPA 8270D	EPA 8270D	----------

Parameter/Analyte	Non-Potable Water	Solid Hazardous Waste	Air
C9-C18 Aliphatic Hydrocarbons	MAEPH	MAEPH	----------
C19-C36 Aliphatic Hydrocarbons	MAEPH	MAEPH	----------
C11-C22 Aromatic Hydrocarbons	MAEPH	MAEPH	----------
Diesel Range Organics (DRO)	EPA 8015	EPA 8015	----------
2-Methylnaphthalene	EPA 8270	EPA 8270	----------
4-Methylphenol (p-Cresol)	EPA 8270	EPA 8270	----------
Toxicity Characteristic Leaching Procedure (TCLP)	EPA 1311	EPA 1311	----------
Synthetic Precipitation Leaching Procedure (SPLP)	EPA 1312	EPA 1312	----------
Corrosivity (pH)	NA	EPA 9040	----------
Paint Filter Liquids Test	NA	EPA 9095	----------
Diethyl ether	EPA 8260	EPA 8260	----------
Ethyl methacrylate	EPA 8260	EPA 8260	----------
Iodomethane (Methyl iodide)	EPA 8260	EPA 8260	----------
Methyl cyclohexane	EPA 8260	EPA 8260	----------
Methyl acetate	EPA 8260	EPA 8260	----------
Isopropyl ether	EPA 8260	EPA 8260	----------

Analytical Method	Prep Method			
	Soil	Water	Air	Waste
EPA 8260B	EPA 5035	EPA 5030B	----------	EPA 5035
EPA 624	----------	EPA 5030B	----------	----------
EPA 625	----------	EPA 3510C	----------	----------
EPA 8270D	EPA 3545A	EPA 3510C	----------	EPA 3580A
EPA 200.7	----------	EPA 200.7	----------	----------
EPA 6010C	EPA 3050B	EPA 3005A	----------	EPA 3050B
EPA 608	----------	EPA 3510C	----------	----------
EPA 8081B	EPA 3545A	EPA 3510C	----------	EPA 3580A
EPA 8082A	EPA 3545A	EPA 3510C	----------	EPA 3580A
EPA 615	----------	EPA 615	----------	----------
EPA 8151A	EPA 8151A	EPA 8151	----------	EPA 8151A
MA VPH, May 2004 Revision 1.1	EPA 5035	EPA 5030B	----------	----------
MA EPH, May 2004 Revision 1.1	EPA 3545A	EPA 3510C	----------	----------
FLPRO	EPA 3545A	EPA 3510C	----------	----------
8015C – GRO	EPA 5035	EPA 5030B	----------	----------
8015C – DRO	EPA 3545A	EPA 3510C	----------	----------
TO14A	----------	----------	TO14A	----------
TO15	----------	----------	TO15	----------
SPLP	EPA 1312	EPA 1312	----------	EPA 1312
TCLP	EPA 1311	EPA 1311	----------	EPA 1311

The American Association for Laboratory Accreditation

World Class Accreditation

Accredited DoD ELAP Laboratory

A2LA has accredited

ENVIRONMENTAL CONSERVATION LABORATORIES - ORLANDO

Orlando, FL

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (QSM v4.1); accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION
CORPORATE SEAL 1978
DISTRICT OF COLUMBIA
A2LA

Presented this 29h day of March 2010.

President & CEO
For the Accreditation Council
Certificate Number 3000.01
Valid to March 31, 2012

For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

ENVIRONMENTAL CONSERVATION LABORATORIES – ORLANDO
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ENVIRONMENTAL

Valid To: March 31, 2012 Certificate Number: 3000.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.1)) accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Analyte / Parameter	**Non-Potable Water**	**Solid Hazardous Waste**
Metals	EPA 6020A/200.8	EPA 6020A
Aluminum	EPA 6020A/200.8	EPA 6020A
Antimony	EPA 6020A/200.8	EPA 6020A
Arsenic	EPA 6020A/200.8	EPA 6020A
Barium	EPA 6020A/200.8	EPA 6020A
Beryllium	EPA 6020A/200.8	EPA 6020A
Cadmium	EPA 6020A/200.8	EPA 6020A
Calcium	EPA 6020A/200.8	EPA 6020A
Chromium	EPA 6020A/200.8	EPA 6020A
Cobalt	EPA 6020A/200.8	EPA 6020A
Copper	EPA 6020A/200.8	EPA 6020A
Hardness	SM 2340 B	----------
Iron	EPA 6020A/200.8	EPA 6020A
Lead	EPA 6020A/200.8	EPA 6020A
Magnesium	EPA 6020A/200.8	EPA 6020A
Manganese	EPA 6020A/200.8	EPA 6020A
Mercury	EPA 245.1/7470A	EPA 7471B
Molybdenum	EPA 6020A/200.8	EPA 6020A
Nickel	EPA 6020A/200.8	EPA 6020A
Potassium	EPA 6020A/200.8	EPA 6020A
Selenium	EPA 6020A/200.8	EPA 6020A
Silver	EPA 6020A/200.8	EPA 6020A

5301 Buckeystown Pike, Suite 350 | Frederick, Maryland 21704-8373 | Phone: 301 644 3248 | Fax: 301 662 2974 | www.A2LA.org

Analyte / Parameter	Non-Potable Water	Solid Hazardous Waste
Sodium	EPA 6020A/200.8	EPA 6020A
Thallium	EPA 6020A/200.8	EPA 6020A
Tin	EPA 6020A/200.8	EPA 6020A
Titanium	EPA 6020A/200.8	EPA 6020A
Vanadium	EPA 6020A/200.8	EPA 6020A
Zinc	EPA 6020A/200.8	EPA 6020A
Microbiology		
Total Coliforms	SM 9222B	----------
Fecal Coliforms	SM 9222D	----------
General Chemistry		
Acidity, as $CaC0_3$	EPA 305.1/SM 2310 B (4A)	----------
Alkalinity as $CaC0_3$	EPA 310.1/SM 2320 B	EPA 310.1/SM 2320 B
Alkalinity as $CaC0_4$	EPA 310.2	EPA 310.2
Ammonia as N	----------	EPA 350.1
Biochemical oxygen demand	EPA 405.1/SM 5210 B	----------
Bromide	EPA 300.0/9056A	EPA 9056A
Carbonaceous BOD (CBOD)	SM 5210 B	----------
Chemical oxygen demand	EPA 410.4	----------
Chloride	EPA 300.0/9056A	EPA 9056A
Chromium VI	EPA 7196/ SM 3500-Cr D	EPA 7196
Conductivity	EPA 120.1	----------
Cyanide	EPA 335.2/SM 4500-CN E	EPA 9014
Ferric iron (calculated)	SM 3500-Fe D	----------
Ferrous iron	SM 3500-Fe D	----------
Fluoride	EPA 300.0/9056A	EPA 9056A
Hardness	EPA 130.2/SM 2340 C	----------
Kjeldahl nitrogen -total	EPA 351.2	EPA351.2
Nitrate as N	EPA 300.0/353.1/9056A	EPA 353.1/9056A
Nitrate-nitrite	EPA 300.0/353.1/9056A	EPA 353.1/9056A
Nitrite as N	EPA 300.0/354.1/9056A/SM 4500-NO_2 B	EPA 9056A/ SM 4500-NO_2 B
Organic nitrogen	EPA 351.2/350.1	EPA 351.2/350.1
Orthophosphate as P	EPA 365.1	----------
Orthophosphate as P	EPA 365.3	----------
pH	EPA 150.1/9040C/SM 4500-H^+-B	EPA 9040C
Phosphorus, total	EPA 365.4	EPA 365.4
Residue-filterable (TDS)	SM 2540 C	----------
Residue-nonfilterable (TSS)	SM 2540 D	----------
Residue-total	SM 2540 B/SM 2540 G/EPA 160.3	SM 2540G/EPA 160.3
Residue-volatile	EPA 160.4	EPA 160.4
Sulfate	EPA 300.0/9056A	EPA 9056A
Sulfide	EPA 376.1/SM 4500-S E	----------
Surfactants -MBAS	SM 5540 C	----------
Total nitrate-nitrite	EPA 9056 A/SM 4500-$N0_3$ H	EPA 9056 A/SM 4500-$N0_3$ H
Total cyanide	EPA 9014	EPA 9014
Total nitrogen	TKN + Total nitrate-nitrite	TKN + Total nitrate-nitrite
Total Organic Carbon	EPA 9060A/SM 5310B	TOC Walkley Black
Total phenolics	EPA 420.1	EPA 420.1
Total, fixed, and volatile residue	SM 2540 G	SM 2540 G
Turbidity	EPA 180.1	----------

Analyte / Parameter	Non-Potable Water	Solid Hazardous Waste
Un-ionized ammonia	DEP SOP 10/03/83	DEP SOP 10/03/83
Extractable Organics		
1,2,4-Trichlorobenzene	EPA 8270D/625	EPA 8270D
1,2,4,5-Tetrachlorobenzene	EPA 8270D/625	EPA 8270D
1,2-Dichlorobenzene	EPA 8270D/625	EPA 8270D
1,3-Dichlorobenzene	EPA 8270D/625	EPA 8270D
1,4-Dichlorobenzene	EPA 8270D/625	EPA 8270D
2,3,4,6-Tetrachlorophenol	EPA 8270D/625	EPA 8270D
2,4,5-Trichlorophenol	EPA 8270D/625	EPA 8270D
2,4,6-Trichlorophenol	EPA 8270D/625	EPA 8270D
2,4-Dichlorophenol	EPA 8270D/625	EPA 8270D
2,4-Dimethylphenol	EPA 8270D/625	EPA 8270D
2,4-Dinitrophenol	EPA 8270D/625	EPA 8270D
2,4-Dinitrotoluene (2,4-DNT)	EPA 8270D/625/ Scan-Sim	EPA 8270D
2,6-Dinitrotoluene (2,6-DNT)	EPA 8270D/625	EPA 8270D
2-Chloronaphthalene	EPA 8270D/625	EPA 8270D
2-Chlorophenol	EPA 8270D/625	EPA 8270D
2·Methyl-4,6-dinitrophenol	EPA 8270D/625	EPA 8270D
2-Methylnaphthalene	EPA 8270D/625	EPA 8270D
2-Methylphenol (o-Cresol)	EPA 8270D/625	EPA 8270D
2-Nitroaniline	EPA 8270D/625	EPA 8270D
2-Nitrophenol	EPA 8270D/625	EPA 8270D
3,3'-Dichlorobenzidine	EPA 8270D/625	EPA 8270D
3/4-Methylphenols (m/p-Cresols)	EPA 8270D/625	EPA 8270D
3-Nitroaniline	EPA 8270D/625	EPA 8270D
4-Bromophenyl phenyl ether	EPA 8270D/625	EPA 8270D
4-Chloro-3-methylphenol	EPA 8270D/625	EPA 8270D
4-Chloroaniline	EPA 8270D/625	EPA 8270D
4-Chlorophenyl phenyl ether	EPA 8270D/625	EPA 8270D
4-Nitrophenol	EPA 8270D/625	EPA 8270D
Acenaphthene	EPA 8270D/625	EPA 8270D
Acenaphthylene	EPA 8270D/625	EPA 8270D
4-Melhylphenol (p-Cresol)	EPA 8270D/625	EPA 8270D
4-Nitroaniline	EPA 8270D/625	EPA 8270D
Acetophenone	EPA 8270D/625	EPA 8270D
Anthracene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Atrazine	EPA 8270D/625	EPA 8270D
Benzaldehyde	EPA 8270D/625	EPA 8270D
Benzidine	EPA 8270D/625/ Scan-Sim	EPA 8270D
Benzo(a)anthracene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Benzo(a)pyrene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Benzo(b)fluoranthene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Benzo(g,h,i)perylene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Benzo(k)fluoranthene	EPA 8270D/625/ Scan-Sim	EPA 8270D
1,1-Biphenyl	EPA 8270D/625	EPA 8270D
bis(2-Chloroethoxy) methane	EPA 8270D/625	EPA 8270D
bis(2-Chloroethyl) ether	EPA 8270D/625	EPA 8270D
bis(2-Chloroisopropyl) ether (2,2'-Oxybis(1-chloropropane))	EPA 8270D/625	EPA 8270D
bis(2-Ethylhexyl) phthalate (DEHP)	EPA 8270D/625	EPA 8270D

Analyte / Parameter	Non-Potable Water	Solid Hazardous Waste
Butyl benzyl phthalate	EPA 8270D/625	EPA 8270D
Caprolactam	EPA 8270D/625	EPA 8270D
Carbazole	EPA 8270D/625	EPA 8270D
Chrysene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Dibenz(a,h)anthracene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Dibenzofuran	EPA 8270D/625	EPA 8270D
Diethyl phthalate	EPA 8270D/625	EPA 8270D
Dimethyl phthalate	EPA 8270D/625/ Scan-Sim	EPA 8270D
Di-n-butyl phthalate	EPA 8270D/625	EPA 8270D
Di-n-octyl phthalate	EPA 8270D/625	EPA 8270D
Fluoranthene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Fluorene	EPA 8270D/625	EPA 8270D
Hexachlorobenzene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Hexachlorobutadiene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Hexachlorocyclopentadiene	EPA 8270D/625	EPA 8270D
Hexachloroethane	EPA 8270D/625	EPA 8270D
Indeno(1,2,3-cd)pyrene	EPA 8270D/625/ Scan-Sim	EPA 8270D
Isodrin	EPA 8270D/625	EPA 8270D
Isophorone	EPA 8270D/625	EPA 8270D
Naphthalene	EPA 8270D/625	EPA 8270D
Nitrobenzene	EPA 8270D/625	EPA 8270D
n-Nitrosodi-n-propylamine	EPA 8270D/625	EPA 8270D
n-Nitrosodiphenylamine	EPA 8270D/625	EPA 8270D
Pentachlorophenol	EPA 8270D/625/ Scan-Sim	EPA 8270D
Phenanthrene	EPA 8270D/625	EPA 8270D
Phenol	EPA 8270D/625	EPA 8270D
Pyrene	EPA 8270D/625	EPA 8270D
Total Petroleum Hydrocarbons (TPH)	FL·PRO	FL·PRO
Volatile Organics		
1,1,1,2-Tetrachloroethane	EPA 8260B/624	EPA 8260B
1,1,1-Trichloroethane	EPA 8260B/624	EPA 8260B
1,1,2,2-Tetrachloroethane	EPA 8260B/624	EPA 8260B
1,1,2-Trichloro-1,2,2-trifluoroethane	EPA 8260B/624	EPA 8260B
1,1,2-Trichloroethane	EPA 8260B/624	EPA 8260B
1,1-Dichloroethane	EPA 8260B/624	EPA 8260B
1,1-Dichloroethene	EPA 8260B/624	EPA 8260B
1,1-Dichloropropene	EPA 8260B/624	EPA 8260B
1,2,3-Trichlorobenzene	EPA 504.1/8260B/624	EPA 8260B
1,2,3-Trichloropropane	EPA 8260B/624	EPA 8260B
1,2,4-Trichlorobenzene	EPA 8260B/624	EPA 8260B
1,2,4-Trimethylbenzene	EPA 8260B/624	EPA 8260B
1,2-Dibromo-3-chloropropane (DBCP)	EPA 504 /504.1/8011/8260B	EPA 8260B
1,2-Dibromoethane (EDB, Ethylene dibromide)	EPA 504 /504.1/8011/8260B	EPA 8260B
1,2-Dichlorobenzene	EPA 8260B/624	EPA 8260B
1,2-Dichloroethane	EPA 8260B/624	EPA 8260B
1,2-Dichloropropane	EPA 8260B/624	EPA 8260B
1,3,5-Trimethylbenzene	EPA 8260B/624	EPA 8260B

Analyte / Parameter	Non-Potable Water	Solid Hazardous Waste
1,3-Dichlorobenzene	EPA 8260B/624	EPA 8260B
1,3-Dichloropropane	EPA 8260B/624	EPA 8260B
1,4-Dichlorobenzene	EPA 8260B/624	EPA 8260B
1,4-Dioxane (1,4-Diethylencoxide)	EPA 8260B/624	EPA 8260B
2,2-Dichloropropane	EPA 8260B/624	EPA 8260B
2-Butanone (Methyl ethyl ketone, MEK)	EPA 8260B/624	EPA 8260B
2-Chloroethyl vinyl ether	EPA 8260B/624	EPA 8260B
2-Chlorotoluene	EPA 8260B/624	EPA 8260B
2-Hexanone	EPA 8260B/624	EPA 8260B
4-Chlorotoluene	EPA 8260B/624	EPA 8260B
4-Methyl-2-pentanone (MIBK)	EPA 8260B/624	EPA 8260B
Acetone	EPA 8260B/624	EPA 8260B
Acetonitrile	EPA 8260B/624	EPA 8260B
Acrolein (Propenal)	EPA 8260B/624	EPA 8260B
Acrylonitrile	EPA 8260B/624	EPA 8260B
Allyl chloride (3-Chloropropene)	EPA 8260B/624	EPA 8260B
Benzene	EPA 8260B/624	EPA 8260B
Bromobenzene	EPA 8260B/624	EPA 8260B
Bromochloromethane	EPA 8260B/624	EPA 8260B
Bromodichloromethane	EPA 8260B/624	EPA 8260B
Bromoform	EPA 8260B/624	EPA 8260B
Carbon tetrachloride	EPA 8260B/624	EPA 8260B
Carbon disulfide	EPA 8260B/624	EPA 8260B
Chlorobenzene	EPA 8260B/624	EPA 8260B
Chloroethane	EPA 8260B/624	EPA 8260B
Chloroform	EPA 8260B/624	EPA 8260B
Chloroprene	EPA 8260B/624	EPA 8260B
cis-1,2-Dichloroethene	EPA 8260B/624	EPA 8260B
cis-1,3-Dichloropropene	EPA 8260B/624	EPA 8260B
Cyclohexane	EPA 8260B/624	EPA 8260B
Dibromochloromethane	EPA 8260B/624	EPA 8260B
Dibromomethane	EPA 8260B/624	EPA 8260B
Dichlorodifluoromethane	EPA 8260B/624	EPA 8260B
Ethyl methacrylate	EPA 8260B/624	EPA 8260B
Hexachlorobutadiene	EPA 8260B/624	EPA 8260B
Ethylbenzene	EPA 8260B/624	EPA 8260B
Iodomethane (Methyl iodide)	EPA 8260B/624	EPA 8260B
Isobutyl alcohol (2-Methyl-l-propanol)	EPA 8260B/624	EPA 8260B
Isopropylbenzene	EPA 8260B/624	EPA 8260B
m+p-Xylenes	EPA 8260B/624	EPA 8260B
Methacrylonitrile	EPA 8260B/624	EPA 8260B
Methyl acetate	EPA 8260B/624	EPA 8260B
Methyl bromide (Bromomethane)	EPA 8260B/624	EPA 8260B
Methyl chloride (Chloromethane)	EPA 8260B/624	EPA 8260B
Methyl methacrylate	EPA 8260B/624	EPA 8260B
Methyl tert-butyl ether (MTBE)	EPA 8260B/624	EPA 8260B
Methylcyclohexane	EPA 8260B/624	EPA 8260B
Methylene chloride	EPA 8260B/624	EPA 8260B
Naphthalene	EPA 8260B/624	EPA 8260B
n-Butylbenzene	EPA 8260B/624	EPA 8260B

Analyte / Parameter	Non-Potable Water	Solid Hazardous Waste
n-Propylbenzene	EPA 8260B/624	EPA 8260B
o-Xylene	EPA 8260B/624	EPA 8260B
Pentachloroethane	EPA 8260B/624	EPA 8260B
p-Isopropyltoluene	EPA 8260B/624	EPA 8260B
Propionitrile (Ethyl cyanide)	EPA 8260B/624	EPA 8260B
sec-Butylbenzene	EPA 8260B/624	EPA 8260B
Styrene	EPA 8260B/624	EPA 8260B
tert-Butylbenzene	EPA 8260B/624	EPA 8260B
Tetrachloroethene (Perchloroethylene)	EPA 8260B/624	EPA 8260B
Toluene	EPA 8260B/624	EPA 8260B
trans-1,2-Dichloroethene	EPA 8260B/624	EPA 8260B
trans-1,3-Dichloropropene	EPA 8260B/624	EPA 8260B
trans-1,4-Dichloro-2-butene	EPA 8260B/624	EPA 8260B
Trichloroethene (Trichloroethylene)	EPA 8260B/624	EPA 8260B
Trichlorofluoromethane	EPA 8260B/624	EPA 8260B
Vinyl acetate	EPA 8260B/624	EPA 8260B
Vinyl chloride	EPA 8260B/624	EPA 8260B
Xylene (total)	EPA 8260B/624	EPA 8260B
Pesticides-Herbicides-PCBs		
2,4,5-T	EPA 8151A /615	EPA 8151A
2,4-D	EPA 8151A /615	EPA 8151A
2,4-DB	EPA 8151A /615	EPA 8151A
3,5-Dichlorobenzoic acid	EPA 8151A /615	EPA 8151A
4.4'-DDD	EPA 8081B/608	EPA 8081B
4.4'-DDE	EPA 8081B/608	EPA 8081B
4,4'·DDT	EPA 8081B/608	EPA 8081B
4-Nitrophenol	EPA 8151A/615	EPA 8151A
Acifiuorfen	EPA 8151A/615	EPA 8151A
Aldrin	EPA 8081B/608	EPA 8081B
alpha-BHC (alpha-Hexachlorocyclohexane)	EPA 8081B/608	EPA 8081B
alpha-Chlordane	EPA 8081B/608	EPA 8081B
Aroclor-1016(PCB-1016)	EPA 8082A/608	EPA 8082A
Aroclor-1221 (PCB-1221)	EPA 8082A/608	EPA 8082A
Aroclor-1232 (PCB-1232)	EPA 8082A/608	EPA 8082A
Aroclor-1242 (PCB-1242)	EPA 8082A/608	EPA 8082A
Aroclor-1248 (PCB-1248)	EPA 8082A/608	EPA 8082A
Aroclor-1254 (PCB-1254)	EPA 8082A/608	EPA 8082A
Aroclor-1260 (PCB-1260)	EPA 8082A/608	EPA 8082A
Azinphos-methyl (Guthion)	EPA 8141B/614	EPA 8141B
Bentazon	EPA 8151A/615	EPA 8151A
beta-BHC (beta-Hexachlorocyclohexane)	EPA 8081B/608	EPA 8081B
Bolstar (Sulprofos)	EPA 8141B/614	EPA 8141B
Chloramben	EPA 8151A/615	EPA 8151A
Chlordane (tech.)	EPA 8081B/608	EPA 8081B
Chlorpynfos	EPA 8141B/614	EPA 8141B
Coumaphos	EPA 8141B/614	EPA 8141B
Dacthal (DCPA)	EPA 8151A/615	EPA 8151A
Dalapon	EPA 8151A/615	EPA 8151A

Analyte / Parameter	Non-Potable Water	Solid Hazardous Waste
delta-BHC	EPA 8081B/608	EPA 8081B
Demeton-o	EPA 8141B/614	EPA 8141B
Demeton-s	EPA 8141B/614	EPA 8141B
Diazinon	EPA 8141B/614	EPA 8141B
Dicamba	EPA 8151A/615	EPA 8151A
Dichlorofenthion	EPA 8141B/614	EPA 8141B
Dichloroprop (Dichlorprop)	EPA 8151A/615	EPA 8151A
Dlchlorovos (DDVP, Dichtorvos)	EPA 8141B/614	EPA 8141B
Dieldrin	EPA 8081B/608	EPA 8081B
Dimethoate	EPA 8141B/614	EPA 8141B
Dinoseb (2-sec-buty1-4 ,6-dinilrophenol, DNB P)	EPA 8151A/615	EPA 8151A
Disulfoton	EPA 8141B/614	EPA 8141B
Endosulfan I	EPA 8081B/608	EPA 8081B
Endosulfan II	EPA 8081B/608	EPA 8081B
Endosulfan sulfate	EPA 8081B/608	EPA 8081B
Endrin	EPA 8081B/608	EPA 8081B
Endrin aldehyde	EPA 8081B/608	EPA 8081B
Endrin ketone	EPA 8081B/608	EPA 8081B
EPN	EPA 8141B/614	EPA 8141B
Ethion	EPA 8141B/614	EPA 8141B
Ethoprop	EPA 8141B/614	EPA 8141B
fensulfothion	EPA 8141B/614	EPA 8141B
fenthion	EPA 8141B/614	EPA 8141B
gamma-BHC (Lindane, gamma-Hexachlorocyclohexane)	EPA 8081B/608	EPA 8081B
gamma-Chlordane	EPA 8081B/608	EPA 8081B
Heptachlor	EPA 8081B/608	EPA 8081B
Heptachlor epoxide	EPA 8081B/608	EPA 8081B
Isodrin	EPA 8081B/608	EPA 8081B
Malathion	EPA 8141B/614	EPA 8141B
MCPA	EPA 8151A/615	EPA 8151A
Merphos	EPA 8141B/614	EPA 8141B
Methoxychlor	EPA 8081B/608	EPA 8081B
Methyl parathion (Parathion. methyl)	EPA 8141B/614	EPA 8141B
Mevinphos	EPA 8141B/614	EPA 8141B
Mirex	EPA 8081B/608	EPA 8081B
Monocrotophos	EPA 8141B/614	EPA 8141B
Naled	EPA 8141B/614	EPA 8141B
Parathion, ethyl	EPA 8141B/614	EPA 8141B
Pentachlorophenol	EPA 8151A/615	EPA 8151A
Phorate	EPA 8141B/614	EPA 8141B
Picloram	EPA 8151A/615	EPA 8151A
Ronnel	EPA 8141B/614	EPA 8141B
Silvex (2A.5-TP)	EPA 8151B/615	EPA 8151B
Stirofos	EPA 8141B/614	EPA 8141B
Sulfotepp	EPA 8141B/614	EPA 8141B
Tetraethyl pyrophosphate (TEPP)	EPA 8141B/614	EPA 8141B
Tokuthion (Prothiophos)	EPA 8141B/614	EPA 8141B
Toxaphene (Chlorinated camphene)	EPA 8081B/608	EPA 8081B
Trichloronate	EPA 8141B/614	EPA 8141B

Preparation Methods

Fraction	Analytical Method	Preparation Method
Cyanide	EPA 9014 EPA 335.2 /SM 4500-CN E	EPA 9010C
TX	EPA 9056A	EPA 5050
Metal water prep	EPA 6020A/200.8	EPA 3005A
Metals soil prep	EPA 6020A	EPA 3050B
Metals TCLP prep	EPA 6020A/200.8	EPA 3010A
Extractable organics and Pesticides water prep	EPA 8270D/625/8081B/8082A/ 608/ 8141B/ 614	EPA 3510C
Extractable organics and Pesticides waste prep	EPA 8270D/625/8081B/8082A/ 608/ 8141B/ 614	EPA 3580A
Extractable organics and Pesticides soil prep	EPA 8270D/625/8081B/8082A/ 608/ 8141B/ 614	EPA 3550C
Organics water and mid-level soil prep	EPA 8260B/624	EPA 5030B
Organics low-level soil prep	EPA 8260B/624	EPA 5035
Soil/water leachate	Wets	ENCO WETS-88
SPLP	Wets, Organics, and Metals	EPA 1312
TCLP	Wets, Organics, and Metals	EPA 1311