Naval Facilities Engineering Systems Command

Naval Facilities Engineering Systems Command Hawaii
JBPHH HI

Final

Site Assessment Work Plan Red Hill Oily Waste Disposal Facility

JOINT BASE PEARL HARBOR-HICKAM OAHU HI

PEARL HARBOR HI FISC SITE 22

PHNC National Priorities List Site

February 2021

Naval Facilities Engineering Systems Command Hawaii
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February 2021

Prepared for NAVFAC Hawaii by
AECOM Technical Services Inc
1001 Bishop Street Suite 1600
Honolulu HI 96813-3698

N62742-12-D-1829
CTO 0063

Worksheet #1: Title and Approval Page

Final
Work Plan
February 2021

Site Assessment Work Plan

Joint Base Pearl Harbor-Hickam

PHNC National Priorities List Site

Prepared for:

Department of the Navy
Naval Facilities Engineering Systems Command, Hawaii

Prepared for NAVFAC Hawaii by:
AECOM Technical Services, Inc.
1001 Bishop Street Suite 1600
Honolulu HI 96813-3698

Prepared under:
Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-12-D-1829, CTO 0063

AECOM CTO Manager: ______________________ 2/5/2021
Frank Cioffi Date

AECOM QA Program Manager: ______________________ 2/5/2021
Scott Lewis Date

NAVFAC Hawaii RPM: ______________________ 2/5/2021
Tracy-Joy Ibarra Date

EXECUTIVE SUMMARY

This work plan (WP) presents the proposed technical approach for evaluating and addressing the detection of total petroleum hydrocarbons (TPH) quantitated as diesel range organics (TPH-d) in groundwater samples collected from the sole remaining monitoring well at the Red Hill Oily Waste Disposal Facility (OWDF), which is located on the island of Oahu approximately 2 miles northeast of the East Loch of Pearl Harbor (WP Supplement Figure 1).

The OWDF was constructed in the 1940s as a collection point for oily waste water generated by the cleaning of the Red Hill Bulk Fuel Storage Facility's (RHSF) 20 large-capacity underground storage tanks (USTs), which are situated approximately 3,000 feet east and topographically upgradient of the site. Historically, the Red Hill USTs (18 of which are active) have stored multiple fuel types, including Diesel Oil, Navy Special Fuel Oil, Navy Distillate, Marine Diesel Fuel (also known as F-76), Aviation Gasoline, Motor Gasoline, Jet Fuel Propellant (JP)-5, and JP-8 (DON 1992). Since the early 2000s, only three of these fuels have been stored in the tanks: JP-5, JP-8, and F-76. A series of two reclamation and disposal pits, the first unlined and its later replacement lined, were constructed at the OWDF in the same approximate location and used intermittently between 1943 and 1986. Each pit functioned similarly: oily waste from periodic cleaning of the Red Hill USTs was pumped into the pit, where recoverable oil was skimmed from the surface and collected in aboveground storage tanks (ASTs) at the site for offsite use and processing. The remaining water either evaporated, infiltrated, or was otherwise disposed of. Operation of the disposal pits ceased in 1986.

During the 1990s, a Phase I Remedial Investigation (RI), a Removal Action, and a Phase II RI were conducted at the site. Upon completion of these activities, petroleum hydrocarbons including polynuclear aromatic hydrocarbons (PAHs) were identified as the primary chemicals of potential concern (COPCs) at the site; the primary source of contamination (the disposal pit and approximately 20 feet of underlying impacted soil) had been removed; COPC concentrations had significantly diminished; the underlying basal aquifer, which is a source of drinking water, was identified as the only potentially complete exposure pathway of concern and was also determined to be free of detectable COPCs and protected by low permeability geologic formations; and no unacceptable risk was found to be present. Consequently, it was concluded that the site fell under the petroleum exclusion to the Comprehensive Environmental Response, Compensation, and Liability Act (DON 2001b) and the Department of Health (DOH) determined that no further action (NFA) was warranted for the site (DOH 2005).

After the DOH issued its NFA determination, all of the wells except one, now referred to as OWDFMW01, were abandoned, and OWDFMW01 was later incorporated into the long-term monitoring (LTM) program for the Red Hill tank farm, which is set forth in the *Red Hill Groundwater Protection Plan* (DON 2008, 2014). Subsequent laboratory analyses of some groundwater samples collected from OWDFMW01 between January 2010 and October 2015 reported the presence of TPH in the basal groundwater at concentrations that exceeded regulatory screening levels. These detections occurred both before and after a confirmed release of JP-8 from RHSF tank no. 5 in 2014. The detection of elevated concentrations of TPH prompted the Navy to propose this site assessment to further investigate the nature and extent of potential impacts to the basal aquifer from the OWDF site and ascertain whether any response actions are warranted.

The proposed investigation of potential impacts to the basal aquifer at the OWDF includes drilling boreholes and installing seven monitoring well clusters, most of which are expected to be comprised of one perched and one basal monitoring well. During drilling, the subsurface will be characterized and select soil samples will be collected for laboratory analyses. Upon completion of the wells, four quarterly groundwater monitoring events will be completed, and samples will be submitted for laboratory analysis. Soil and groundwater samples will be analyzed for total petroleum hydrocarbons, volatile organic compounds, semivolatile organic compounds, polynuclear aromatic hydrocarbons, and dioxins and furans. As described in detail in this WP, groundwater samples will also be analyzed for other chemical and natural attenuation parameters, including pH, which has been reported to be elevated in OWDFMW01, and soil samples will also be analyzed for additional geotechnical and fate and transport-related parameters. Any groundwater samples with detectable concentrations of TPH will also be analyzed using silica gel cleanup, in order to quantify the fraction of TPH that either originates from non-petroleum sources or provides evidence of ongoing natural attenuation.

A basal groundwater elevation transducer study will be conducted to evaluate the localized flow patterns in and around the OWDF and the Navy's nearby drinking water supply well.

Data collected from the investigation will be used to perform chemical forensics to evaluate the nature of the impacts that have been reported as "total petroleum hydrocarbons," as well as additional groundwater flow and fate and transport analyses. If warranted, a risk assessment will be conducted consistent with DOH guidance, and the need for potential response actions will be evaluated.

CONTENTS

APPENDIXES

TABLES

ACRONYMS AND ABBREVIATIONS

µg/L	microgram per liter
°F	degree Fahrenheit
AOC	Administrative Order on Consent
AST	aboveground storage tank
AVGAS	aviation gasoline
bgs	below ground surface
BWS	Board of Water Supply, City and County of Honolulu
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	chemical of potential concern
CSM	conceptual site model
DL	detection limit
DLA	Defense Logistics Agency
DO	dissolved oxygen
DoD	Department of Defense, United States
DOH	Department of Health, State of Hawaii
DQO	data quality objective
EAL	environmental action level
EAOC	exposure area of concern
EDD	electronic data deliverable
EHE	environmental health evaluation
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency, United States
ft	foot or feet
GPS	global positioning system
GRO	gasoline range organics
HDOT	Department of Transportation, State of Hawaii
ID	identification
IDW	investigation-derived waste
JBPHH	Joint Base Pearl Harbor-Hickam
JP	Jet Fuel Propellant
K	hydraulic conductivity
LNAPL	light nonaqueous-phase liquid
LOD	limit of detection
LOQ	limit of quantitation
LTM	long-term monitoring
meq/L	milliequivalents per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MOGAS	motor vehicle gasoline
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
NAP	natural attenuation parameter

NAVFAC	Naval Facilities Engineering Systems Command
NAVSUP FLCPH	Naval Supply Systems Command Fleet Logistics Center Pearl Harbor
NFA	no further action
no.	number
NSFO	Navy Special Fuel Oil
OWDF	Oily Waste Disposal Facility
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-dioxin
PCDF	polychlorinated dibenzo-furan
PQO	project quality objective
PSD	particle size distribution
PSL	project screening level
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RHSF	Red Hill Bulk Fuel Storage Facility
RI	remedial investigation
RSL	regional screening level
SGC	silica gel cleanup
SIP	stable isotope probing
SOP	standard operating procedure
SSRBL	site-specific risk-based level
SVOC	semivolatile organic compound
TGM	Technical Guidance Manual
TIC	tentatively identified compound
TOC	total organic carbon
TPH	total petroleum hydrocarbons
U.S.	United States
U.S.C.	United States Code
UDA	unauthorized discharge area
UPD	underground piping and delivery
UST	underground storage tank
VOC	volatile organic compound
WP	work plan

Worksheet #2: Work Plan Identifying Information

Site Name/Number:	Red Hill Oily Waste Disposal Facility (Pearl Harbor FISC Site 00022)
Operable Unit:	Joint Base Pearl Harbor-Hickam
Contractor Name:	AECOM Technical Services, Inc.
Contract Number:	N62742-12-D-1829
Contract Title:	Comprehensive Long-Term Environmental Action Navy IV
Work Assignment Number (optional):	CTO 0063

1. This work plan (WP) was prepared in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Project Plans* (DoD 2005), the United States Environmental Protection Agency *Guidance for Quality Assurance Project Plans, EPA QA/G-5* (EPA 2002), and consistent with the *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (TGM) (DOH 2018).
2. The regulatory program is the Hawaii State Contingency Plan, codified at Hawaii Administrative Rules, Title 11, Chapter 451.
3. This WP is a project-specific WP.
4. List organizational partners (stakeholders) and identify the connection with lead organization:

Organization Partner/Stakeholder	Role
Naval Facilities Engineering Systems Command, Hawaii	Lead Organization
State of Hawaii Department of Health	Lead Regulatory Agency
United States Environmental Protection Agency Region 9	Stakeholder

5. Lead organization: Naval Facilities Engineering Systems Command, Hawaii
6. If any required WP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted WP elements and provide an explanation for their exclusion below:

   All WP elements are applicable to the project, and no WP elements are provided elsewhere.

Worksheet #3: Distribution List

Work Plan Recipient	Title	Organization	Telephone Number	E-mail Address
Tracy-Joy Ibarra	RPM	NAVFAC Hawaii	808-471-4617	tracy-joy.ibarra@navy.mil
Kim Markillie	QA Manager	NAVFAC Pacific	808-472-1465	kimberly.markillie@navy.mil
Maria Reyes	Regulatory Project Manager	DOH	808-586-4249	maria.reyes@doh.hawaii.gov
Christopher Lichens	Stakeholder (Regulatory Project Manager)	EPA Region 9	415-972-3149	lichens.christopher@epa.gov
Lyndsey Tu	Stakeholder (Regulatory Project Manager)	EPA Region 9	415-972-3269	tu.lyndsey@epa.gov
Frank Cioffi	CTO Manager	AECOM	808-223-7168	frank.cioffi@aecom.com
Scott Lewis	QA Program Manager	AECOM	808-356-5329	scott.lewis@aecom.com
Carolina Anchieta	Deputy CTO Manager	AECOM	808-356-5364	carolina.anchieta@aecom.com
John (Jack) Kronen	Field Manager	AECOM	808-954-4507	john.kronen@aecom.com

AECOM	AECOM Technical Services, Inc.
CTO	contract task order
DOH	Department of Health, State of Hawaii
NAVFAC	Naval Facilities Engineering Systems Command
QA	quality assurance
RPM	remedial project manager

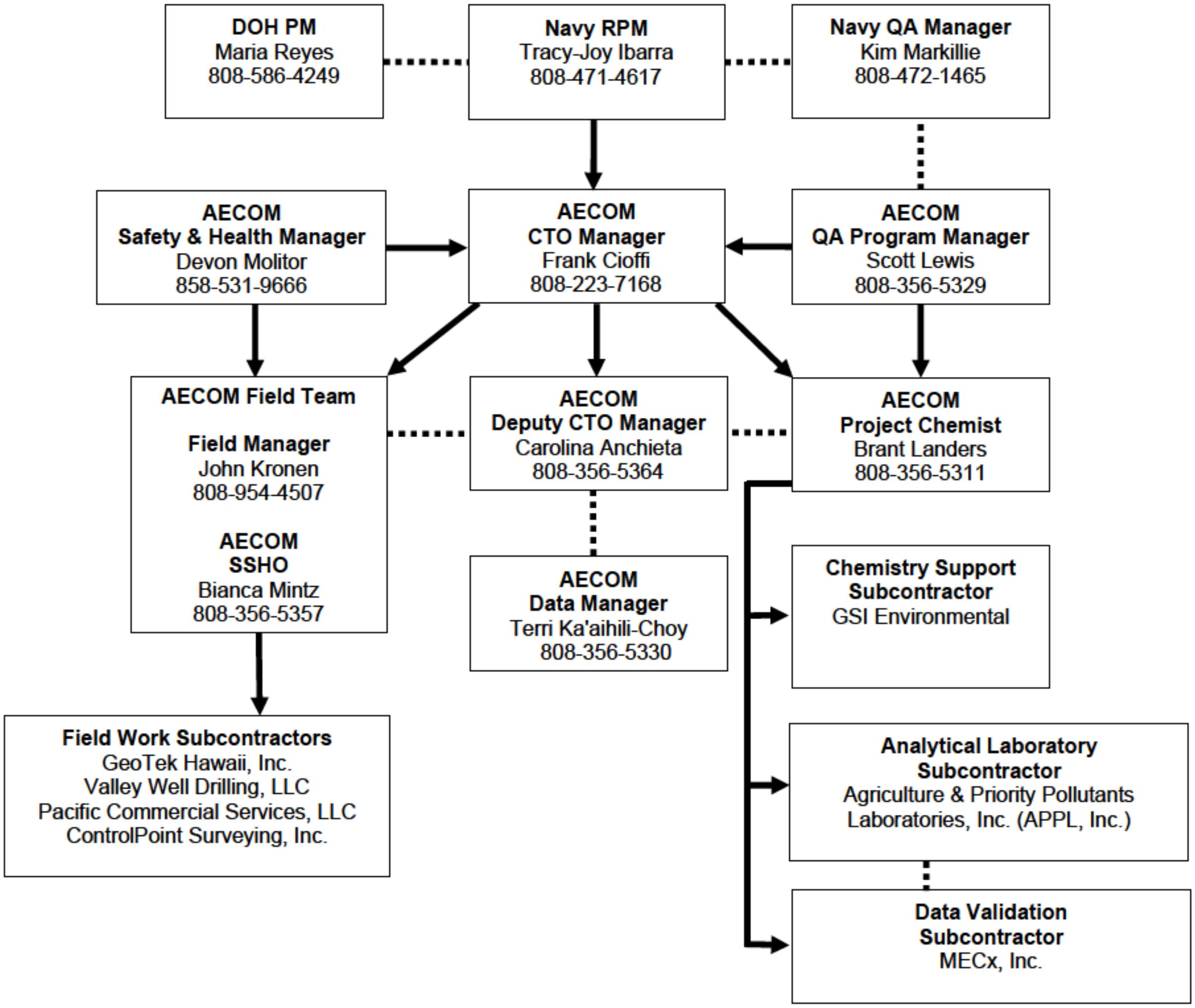
Worksheet #4: Project Personnel Sign-Off Sheet

Listed below are key personnel who are required to read and understand the work plan (WP) prior to performing field activities. The contract task order manager or designee will send an acknowledgement e-mail form with a link to the WP to the key personnel listed below. Upon completion of review of the WP, the personnel will acknowledge that they have read the WP by checking the acknowledgement box in the e-mail form and reply (send) to the originator of the e-mail. A record of the acknowledgement will be automatically documented. The acknowledgement document will be appended to project records. The WP will be reviewed verbally with the project personnel listed below in project kick-off meeting prior to field activities to verify the personnel understand the WP.

Project Personnel	Organization, Title
Frank Cioffi	AECOM, CTO Manager
Scott Lewis	AECOM, QA Program Manager
Carolina Anchieta	AECOM, Deputy CTO Manager
John (Jack) Kronen	AECOM, Field Manager
Bianca Mintz	AECOM, SSHO
Brant Landers	AECOM, Project Chemist

Worksheet #5: Project Organizational Chart

Lines of Authority ——— Lines of Communication ....



Worksheet #6: Communication Pathways

The communication pathways for the WP are shown below.

Communication Driver	Responsible Entity	Name	Phone Number	Procedure
Regulatory Agency Interface	Navy RPM	Tracy-Joy Ibarra	808-471-4617	All project documentation will be forwarded by the Navy RPM. The Navy RPM will be responsible for communicating periodic updates on the project with the stakeholders and for notifying DOH when significant changes or corrective response actions occur. Corrective response actions will be communicated within 24 hours.
Project Management	AECOM CTO Manager	Frank Cioffi	808-223-7168	The AECOM CTO manager will direct and approve all communication to the Navy's RPM and provide monthly status reports to the Navy contracting officer. The AECOM CTO manager will notify the Navy RPM of field changes or modifications by close of business the following day.
QA/QC Management	AECOM QA Program Manager	Scott Lewis	808-356-5329	The AECOM QA program manager will designate responsible project quality personnel to perform specified QA and QC activities and report to project and program management. Issues and non-conformances, and corrective actions will be reported to NAVFAC Pacific QA manager within one day of non-conformance issuance.
Field Progress Reports	AECOM Field Manager	John (Jack) Kronen	808-954-4507	The AECOM field manager will communicate relevant field information to the CTO manager and AECOM project chemist daily during field activities, by phone or e-mail.
Stop Work Due to Safety Issues	All Field Staff	All Field Staff	N/A	All Field Staff have the authority to stop work by field subcontractors or field sampling personnel. Field work will only restart upon satisfactory implementation of the appropriate response actions.
WP Changes Prior to Field/Laboratory work	AECOM CTO Manager	Frank Cioffi	808-223-7168	Substantial changes to the planning documents will require the AECOM CTO manager to prepare amended worksheets before the activities begin.
WP Changes in the Field	AECOM Field Manager	John (Jack) Kronen	808-954-4507	The AECOM field manager will notify the CTO manager of changes to the procedures specified in the WP and other issues that arise during field activities. The AECOM CTO manager will determine the appropriate course of action and document any changes in the Site Assessment report.
Field Corrective Actions	AECOM Field Manager	John (Jack) Kronen	808-954-4507	The AECOM field manager will have the authority to stop work and issue corrective response actions to field sampling personnel. Modes of communications will be by telephone or e-mail within 24 hours.
Daily COC Reports and Shipping Documentation	AECOM Field QC Coordinator/SSHO	Bianca Mintz	808-356-5357	COCs and shipping records will be submitted via fax or e-mail to the AECOM project chemist at the end of each day that samples are collected.
Sample Receipt Variances	Laboratory Project Manager	Libby Cheeseborough	559-862-2109	All variances in sample receipt will be reported to the AECOM project chemist by the laboratory within 24 hours of occurrence. A signed copy of the COCs and a completed Sample Condition Report will be provided to the project chemist within 24 hours of sample receipt.

Communication Driver	Responsible Entity	Name	Phone Number	Procedure
Reporting Laboratory Data Quality Issues	Laboratory Project Manager	Libby Cheeseborough	559-862-2109	Laboratory data quality issues that potentially affect data usability will be reported by the laboratory project manager to the project chemist by e-mail within one business day. If significant problems are identified from the laboratory that impacts the usability of the data, the project chemist will inform the Navy remedial project manager within one day of notification.
	Navy RPM	Tracy-Joy Ibarra	808-471-4617	If significant problems with the laboratory are identified, the Navy remedial project manager will inform the Navy Quality Assurance manager for evaluation to determine what corrective actions will be taken.
Reporting Laboratory Quality Variances	Laboratory Project Manager	Libby Cheeseborough	559-862-2109	All laboratory quality variance issues will be reported to AECOM project chemist by the laboratory within one day of variance. Any variance will be reported to the AECOM CTO manager the same business day and to the Navy within 2 business days.
Analytical Corrective Actions	AECOM Project Chemist	Brant Landers	808-356-5311	The AECOM project chemist will immediately notify the AECOM CTO manager and the laboratory project manager by e-mail of any field or analytical procedures that were not performed in accordance with the planning documents. The AECOM project chemist will document the non-conformance and issue the corrective actions to be taken and will verify implementation of the corrective actions by the laboratory.
Reporting Data Validation Issues	Data Validation Project Manager	Elizabeth Wessling	713-585-7000	The data validation project manager will report any data validation issue in writing to the AECOM project chemist. The data validation project manager will generate memos to the laboratory regarding incomplete deliverables or discrepancies. Any issues will also be reported in writing to the AECOM CTO manager or the project chemist within one business day.
Data Validation Corrective Actions	AECOM Analytical & Data Validation Advisor	Terri Ka'aihili-Choy	808-356-5330	The AECOM analytical and data validation advisor will have the authority to issue corrective response actions to laboratory and data validation firms. Corrective actions may be issued to the laboratory as a result of data validation results. Modes of communications will be by telephone or e-mail within 24 hours after audit.

AECOM	AECOM Technical Services, Inc.
COC	chain of custody
CTO	contract task order
DOH	Department of Health, State of Hawaii
EPA	Environmental Protection Agency, United States
NAVFAC	Naval Facilities Engineering Systems Command
QA	quality assurance
QC	quality control
RPM	remedial project manager
SSHO	site safety and health officer
WP	work plan

Worksheet #7: Personnel Responsibilities Table

Project-specific responsibilities are provided in the following table.

Name	Title	Organizational Affiliation	Responsibilities
Tracy-Joy Ibarra	Navy RPM	NAVFAC Hawaii	Coordinates with Regulatory Agencies and other stakeholders. Contract technical administration and project oversight.
Maria Reyes	Regulatory Project Manager	DOH	Provides regulatory oversight for the project.
Kim Markillie	QA Manager	NAVFAC Pacific	Provides QA surveillance during the procurement process and, following award of contract, monitors compliance with contract and project performance standards.
Robin Cababa	CLEAN IV Program Manager	AECOM	Ensures compliance with contractual and technical procedures across the program.
Scott Lewis	QA Program Manager	AECOM	Reviews all technical procedures. Oversees project QA and ensures that overall technical direction correlates with other Navy CLEAN sites.
Frank Cioffi	CTO Manager	AECOM	Coordinates with the Navy and provides overall technical direction and guidance for the project. Shares responsibility with the Navy RPM for distribution of project-related documents. Identifies project problems or non-conformance and initiates corrective action.
Bianca Mintz	SSHO (onsite)/ Field QC Coordinator	AECOM	Implements the Site-Specific accident prevention plan; prepares, implements, oversees the AHAs; conducts daily tailgate health and safety meeting. Maintains the QA/QC field logbook, ensures collection of QA/QC samples as proposed in the WP and documents collection. Provides QC review of field logbook maintained by the AECOM field manager.
Devon Molitor	Safety and Health Manager	AECOM	Directs and oversees accident prevention plan and procedure.
John (Jack) Kronen	Field Manager	AECOM	Plans and oversees the implementation of field sampling, monitors adherence to activity-specific SOPs, and coordinates subcontractors in the field.
Bianca Mintz	Field Geologist	AECOM	Identifies sampling locations, directly oversees utility clearing, vegetation clearing, and intrusive activities (e.g., well installations). Describes soil and records the description in sampling logs and records well construction details.
Brant Landers	Project Chemist	AECOM	Provides specific technical assistance for the project including development of the project work and analytical plans and reporting document. Assists with analytical laboratory and data validation procurement, oversight, management, and coordination. Oversees all field sampling activities to ensure adherence to the WP. Coordinates with the analytical laboratory and data validation firms. Reviews and evaluates analytical data and summarizes data validation reports. Assists with sample collection, as needed.
Terri Ka'aihili-Choy	Analytical & Data Validation Advisor	AECOM	Assists with analytical and data validation, as well as data usability issues.
Terri Ka'aihili-Choy	Database Manager	AECOM	Manages and maintains the project database, provides data reports on an as-needed basis.
Libby Cheeseborough	Laboratory Manager	APPL	Manages analytical data generation.
Sharon Dehmlow	Laboratory QA Officer	APPL	Performs laboratory QA oversight.
Elizabeth Wessling	Data Validation Task Manager	MECx	Manages analytical data validation produced by the laboratory.
Ileana Rhodes	Chemistry Support Subcontractor	GSI Environmental, Inc.	Provides analytical data evaluation support.
Jingbo Chang	Vegetation Clearance Subcontractor	PCS	Performs vegetation clearance and green waste disposal generated on this project.
Alden Kajioka	Land Survey Subcontractor	ControlPoint Surveying, Inc.	Conducts land survey for special representation of SA sampling locations.

Name	Title	Organizational Affiliation	Responsibilities
Kevin Rogers	Geophysical Survey Subcontractor	GeoTek Hawaii, Inc.	Conducts subsurface utility clearance and geophysical survey before collecting subsurface soil samples.
Kevin Rogers	Drilling Subcontractor	GeoTek Hawaii, Inc.	Performs drilling activities (i.e., subsurface soil borings and well installations) for perched aquifer wells.
Mike Sober	Drilling Subcontractor	Valley Well Drilling, LLC	Performs drilling activities (i.e., subsurface soil borings and well installations) for basal aquifer wells.
Jingbo Chang	IDW Subcontractor	PCS	Disposes of IDW generated on this project.

AHA	activity hazard analysis
AECOM	AECOM Technical Services, Inc.
CLEAN	Comprehensive Long-Term Environmental Action Navy
CTO	contract task order
IDW	investigation-derived waste
NAVFAC	Naval Facilities Engineering Systems Command
QA	quality assurance
QC	quality control
RPM	remedial project manager
SA	Site Assessment
PCS	Pacific Commercial Services, LLC
SOP	standard operating procedure
WP	work plan

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
Not Applicable						

Worksheet #9: Project Scoping Session Participants Sheet

Project Name: Site Assessment at the Red Hill Oily Waste Disposal Facility
Projected Date(s) of Sampling: July 2020
Contract Task Order Manager: Frank Cioffi

Site Name: Red Hill Oily Waste Disposal Facility
Site Location: JBPHH Oahu HI

Date of Session: February 13, 2019
Scoping Session Purpose: Discuss project objectives, outline proposed scope, and conduct a site visit

Name	Project Role	Affiliation	Phone #	E-mail Address
Tracy-Joy Ibarra	NAVFAC Hawaii RPM – Red Hill OWDF	NAVFAC Hawaii	808-471-4617	tracy-joy.ibarra@navy.mil
Jan Kotoshirodo	NAVFAC Hawaii RPM	NAVFAC Hawaii	808-471-4615	jan.kotoshirodo@navy.mil
Clint Zenigami	Acting NAVFAC Hawaii EV3 Program Manager	NAVFAC Hawaii	808-471-4610	clint.zenigami@navy.mil
Maria Reyes	DOH RPM	DOH	808-586-4249	maria.reyes@doh.hawaii.gov
Beryl Ekimoto	DOH RPM	DOH	808-586-4249	beryl.ekimoto@doh.hawaii.gov
Christopher Lichens	EPA Region 9 RPM	EPA	415-972-3149	lichens.christopher@epa.gov
John Chesnutt	EPA Region 9 Federal Facilities Program Manager	EPA	415-972-3005	chesnutt.john@epa.gov
Daniel Stralka	EPA Region 9 Human Health Risk Assessor	EPA	415-972-3048	stralka.daniel@epa.gov
Ned Black	EPA Region 9 Ecological Risk Assessor	EPA	415-972-3055	black.ned@epa.gov
Frank Cioffi	CTO-63 CTO Manager	AECOM	808-223-7168	frank.cioffi@aecom.com
Carolina Anchieta	CTO-63 Deputy CTO Manager	AECOM	808-356-5364	carolina.anchieta@aecom.com
Thomas Henderson	CTO Manager	AECOM	808-356-5382	thomas.henderson2@aecom.com
Jeff Johnson	CLEAN Program Manager	AECOM	808-356-5340	jeff.johnson@aecom.com
Yueh Chuang	CTO Manager	AECOM	808-356-7259	yueh.chuang@aecom.com

AECOM	AECOM Technical Services, Inc.
DOH	Department of Health, State of Hawaii
EPA	Environmental Protection Agency, United States
EV3	Environmental Restoration
HI	Hawaii
JBPHH	Joint Base Pearl Harbor-Hickam
NAVFAC	Naval Facilities Engineering Systems Command
OWDF	Oily Waste Disposal Facility
RPM	remedial project manager

Comments/Discussions: The following topics were discussed during the scoping session: historical site use; results of previous investigations; Site Assessment purpose and overall goals, and general scope of proposed fieldwork, including current site conditions, sampling media, logistics; and the anticipated project schedule, which will require prompt review of planning documents. A work plan is currently being developed for regulatory review to investigate the detection of total petroleum hydrocarbons in the basal aquifer and assess whether any unacceptable risk is present or whether any response actions are warranted. The scoping session consisted of a meeting followed by a site visit.

Worksheet #10: Conceptual Site Model

This work plan (WP) presents the proposed sampling and analysis program for a Site Assessment at the Red Hill Oily Waste Disposal Facility (OWDF), Joint Base Pearl Harbor-Hickam (JBPHH), Oahu, Hawaii (WP Supplement Figure 1). The OWDF was the site of reclamation and disposal pits that served as holding and settling ponds for bottom sludge and rinse water generated during cleaning of the Red Hill Bulk Fuel Storage Facility (RHSF) underground storage tanks (USTs). In the 1990s and early 2000s, the Navy conducted a remedial investigation (RI) and removal action at the OWDF, which included investigating the nature and extent of contamination at the site, removing petroleum-impacted sludge and soil, and assessing the risk to human health and the environment. The RI concluded that the site did not pose a threat to human health or the environment (DON 2000). Based on the findings in the RI, the State of Hawaii Department of Health (DOH) and the United States (U.S.) Environmental Protection Agency (EPA) agreed that the OWDF was impacted solely by petroleum hydrocarbons, and therefore would be regulated by the DOH pursuant to the Hawaii Environmental Response Law (Chapter 128D, Hawaii Revised Statutes), rather than by the EPA pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), despite the site being listed on the federal National Priorities List (DON 2001a). DOH concurred with the findings and recommendations in the RI and in 2005 issued a no further action (NFA) determination for the site (DOH 2005).

One of the three basal groundwater monitoring wells installed during the RI (formerly named MW08, now referred to as OWDFMW01) remains in place and has been included in the Red Hill groundwater monitoring network since 2009 (DON 2010). Several chemicals of potential concern (COPCs) have been detected at OWDFMW01 during the Red Hill groundwater long-term monitoring (LTM) program. For groundwater samples collected from OWDFMW01 during quarterly monitoring events in 2010, 2012, 2013, and 2015, laboratory-reported concentrations of total petroleum hydrocarbons (TPH) quantitated as diesel range organics (TPH-d) exceeded the regulatory screening criterion. However, the chromatographic signatures of these TPH-d detections indicate chemical profiles dissimilar to petroleum fuel standards. In addition to TPH-d, TPH quantitated as residual range organics (TPH-o), benzene, toluene, total xylenes, 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene were occasionally detected at concentrations well below their screening criteria. Although TPH-d has reportedly exceeded the screening level during the events listed above, no individual compound or constituent has exceeded the screening levels during any LTM event, and the chromatograms do not appear to be attributable to a recent release of petroleum.

Because the basal groundwater aquifer under the OWDF serves as a principal drinking water source for both the Navy and the City and County of Honolulu, the Navy consulted with DOH and decided to re-evaluate the conditions at the Red Hill OWDF site by conducting the Site Assessment described herein. The proposed Site Assessment will be conducted consistent with the DOH's *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (TGM) (DOH 2018), in the following stages to achieve the following objectives:

1. *Site Investigation:* The site investigation will re-evaluate conditions at the site and in the underlying aquifers to evaluate the nature and extent of the reported TPH-d concentrations in OWDFMW01 in recent years.
2. *Environmental Health Evaluation (EHE):* The EHE will determine the presence or absence of potential environmental hazards by integrating the findings and data from the OWDF and RHSF investigations to update the conceptual site model (CSM) for the OWDF site, evaluate fate and transport processes, evaluate ongoing biodegradation and natural attenuation processes, and conduct a human health risk assessment.

3. *Response Action Determination:* Based on the foregoing, the Site Assessment will make appropriate recommendations such as whether the NFA determination remains valid or whether specific response actions are warranted.

Field activities will include advancement of borings and completion of new groundwater monitoring wells, along with sampling and analysis of the subsurface soil and groundwater. This WP has been prepared to document the anticipated field activities for the U.S. Department of the Navy, Naval Facilities Engineering Systems Command, Pacific, under the U.S. Navy's Comprehensive Long-Term Environmental Action Navy IV program, contract number (no.) N62742-12-D-1829, contract task order no. 0063. This WP was prepared based on the following regulatory and Navy guidance:

- *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual* (DoD 2005)
- *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015)
- *Department of the Navy Environmental Restoration Program Manual* (DON 2018a)
- *Interim Final Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (DOH 2018)

10.1 SITE DESCRIPTION, HISTORY, AND ENVIRONMENTAL SETTING

10.1.1 Site Description and History

The OWDF is located on the island of Oahu approximately 2 miles northeast of the East Loch of Pearl Harbor (WP Supplement Figure 1). The site is located in the Ko‘olau foothills on sloping terrain approximately 120-150 feet (ft) above mean sea level (msl), south of the channelized portion of South Halawa Stream. The OWDF is situated within the boundaries of the 144-acre RHSF, which is owned by the Defense Logistics Agency (DLA) and operated by Naval Supply Systems Command Fleet Logistics Center Pearl Harbor (NAVSUP FLCPH). Following is a brief description of relevant historical operations at the OWDF, the nearby drinking water supply well Red Hill Shaft, and the RHSF.

10.1.1.1 OWDF DESCRIPTION AND HISTORY

The two-phase OWDF RI (DON 1996a, 2000) identified two different reclamation and disposal pits and basins, which operated during separate periods in the same approximate location at the OWDF, as the primary sources of petroleum impacts at the site (WP Supplement Figure 2). Between 1943 and 1986, the "Oily Waste Disposal Pit" and the "Stilling Basin" successively operated as holding and settling ponds for bottom sludge, rinse water, and other oily waste generated at RHSF during tank cleaning operations. Both pits functioned similarly: oily wastewater generated from periodic cleaning of the RHSF USTs was pumped into the pit, where recoverable oil was skimmed from the surface. The recovered oil was transferred to holding tanks and then to trucks for transport to a fuel processing facility at Pearl Harbor. The remaining water was left to evaporate or infiltrate, and was also directed into channelized South Halawa Stream, which is located approximately 300 ft north of the pits (DON 1996a).

As shown on the Site Plan (WP Supplement Figure 2), several potential exposure areas of concern (EAOCs) were identified for investigation during the RI, including:

- *Oily Waste Disposal Pit:* The original Oily Waste Disposal Pit was constructed in 1943 as an earthen-bermed pit with a 25-square-ft base that was lined with lava rock. Oily waste was deposited into the pit for treatment via evaporation, settling, skimming, burning, and percolation

(DON 1988). The pit operated from 1943 until 1948, when it was excavated to a point below visible subsurface contamination. At least one attempt was made to burn off the pit-bottom sludge with gasoline, which was reportedly largely unsuccessful (NEESA 1983; DON 1992).

- *Stilling Basin:* In 1972, the 25-ft × 40-ft Stilling Basin was constructed in the same approximate location and used in essentially the same manner as the original Oily Waste Disposal Pit. The Stilling Basin, however, was lined—first with asphalt, which began to crack and was therefore replaced with concrete. The Stilling Basin was active from 1972 to 1986, and was removed from service by 1987 after an initial subsurface investigation of the site (DON 1988). The Stilling Basin was completely removed, along with associated piping and approximately 20 ft of underlying soil, during a 1995 Removal Action (DON 1996b), as described below. The excavation covered an area of approximately 10,000 square feet and had a maximum vertical extent of approximately 28 feet bgs (i.e., above the perched aquifer). The excavated soil was transported off site for treatment by thermal desorption and used as clean backfill in the excavation. To prevent rainfall recharge at the site, the soil was graded to assure positive drainage away from the former excavation, and most of the Stilling Basin area was capped with a low-permeability liner and asphaltic pavement. The area is now occasionally used for parking and as a staging area (WP Supplement Figure 3).
- *Two 8,000-Gallon Aboveground Storage Tanks (ASTs) ("Two ASTs Area"):* During operation of the Oily Waste Disposal Pit, two tanks situated on a localized topographic high point approximately 100 ft east of the pit were used as holding tanks for the recovered oil before transferring the liquid to trucks for offsite processing. Between 1948 and 1972, after decommissioning of the Oily Waste Disposal Pit and before the Stilling Basin was constructed, oily wastewater from the Red Hill UST cleaning was stored directly in the two 8,000-gallon ASTs pending transport to Pearl Harbor for processing. The two tanks were removed in 1999 to accommodate installation of a reserve electrical generator and a 5,000-gallon AST underlain by an extensive concrete pad (DON 2003).
- *AST Manway Cover Leak:* In 1972, a 40,000-gallon AST (Tank 311) was installed approximately 30 ft southeast of the Stilling Basin to replace the function of the two 8,000-gallon ASTs. After the Stilling Basin was decommissioned in 1987, the 40,000-gallon AST served as the primary oily waste storage facility at the RHSF. In the 1990s, RI investigators reported that the manway cover and soil in the vicinity of the AST were stained, indicating a potential release. Subsequently, surface soil samples were collected in the vicinity of this manhole cover and analyzed for VOCs, SVOCs, TPH, organolead, and metals. The analytical results indicated detections of SVOCs, TPH, and metals in surface soils below the project screening criteria. The RI concluded that impacts to this area are probably related to historical leaks in the tank manway cover gasket and the general transfer of product to and from the tank. No further action was recommended at Tank 311 based on the assessment of nature and extent of contamination, fate and transport assessment, and risk evaluation. After the 1995 Removal Action, an 8-ft-high concrete retaining wall and lined berm were constructed around the AST. Tank 311 currently remains in use at the site.
- *Underground Piping and Delivery (UPD) System:* Oily wastewater generated at the RHSF USTs was transported to the disposal pit and basin and associated transfer and collection facilities (i.e., the onsite ASTs and a truck fill stand) by a system of underground pipes and valves. Piping also led toward South Halawa Stream. The UPD system was initially installed in 1943 along with the Oily Waste Disposal Pit and was expanded in 1972 during construction of the Stilling Basin. Most portions of the UPD system beneath the Stilling Basin and leading to South Halawa Stream were excavated and removed during the 1995 Removal Action. Only

two sections of piping were grouted, capped, and abandoned in place. These sections include a 10-inch gravity drain, flowing northwest away from the Stilling Basin, and a short section of 10-inch pipe which could not be removed because of its location under a concrete slab (WP Supplement Figure 4) (DON 1996b).

- *Unauthorized Discharge Area:* The Unauthorized Discharge Area (UDA) is a heavily vegetated area approximately 100–150 ft southwest of the Stilling Basin where two separate historical releases may have occurred. During the first event, prior to rebuilding the Stilling Basin's original asphalt lining in 1972, the basin was drained and bottom sludges were reportedly put in 55-gallon drums that were taken a short distance west of the pit and emptied onto surface soil. Later, in the early 1980s, a commercial contractor responsible for hauling wastes from the site to the Navy's reclamation facility was discovered dumping waste material in the UDA. Release quantities and durations for these events are unknown (DON 1988, 1992).
- *Suspected Release Area:* A former RHSF employee reported that approximately 30,000 barrels of fuel, or 1.3 million gallons, were released from the RHSF sometime around 1943–1945. The release was said to have been caused by improper valve operation during routine fueling of a naval vessel in Pearl Harbor. The former employee alleged that the fuel flowed downhill in the RHSF UST access tunnel, where it discharged to the ground at the OWDF and flowed westward into South Halawa Stream. This release was not confirmed, however, and a former Supply Center Fuel Department superintendent stated that this purported release may not have occurred (DON 1996a).
- *Site Runoff Area:* The Site Runoff Area is located topographically downgradient from the site, northwest of the active areas of the site along the perimeter of the south bank of South Halawa Stream and near the outfalls of the two former pipes reportedly used to discharge oily waste water into the stream (DON 1996a). Based on surface topography, the RI hypothesized that the area may have been impacted due to drainage patterns.
- *Former Transformer Area:* Transformers formerly located adjacent to the Two ASTs Area were removed by 1949. Site constructions photographs taken in 1943 show that transformers were located on site adjacent to the two 8,000-gallon ASTs. However, subsequent aerial photos taken in 1949 and thereafter indicate that the transformers were likely removed from the site prior to 1950s. The Former Transformer Area was not believed to be impacted by oily wastes but was investigated because the transformers located on site prior to 1949 posed a potential source of PCBs (DON 1996a). The Phase I RI collected twelve primary samples from trenches, shallow soil borings, and surface soil locations in this area. Trench samples were analyzed for VOCs, PAHs, TPH, pesticides, organolead, and metals. The shallow and surface locations were analyzed for PCBs only. Aroclor 1260 was detected in four samples with detected concentrations ranging from 0.1 to 0.48 mg/kg, all of which are below the current total PCB DOH EAL (1.2 mg/kg [DOH 2018]). The RI concluded that contamination at this exposure area of concern (EAOC) did not represent a significant risk to human health or the environment, and no further action was recommended for this EAOC (DON 1996a), and DOH later agreed.

10.1.1.2 RED HILL SHAFT DESCRIPTION AND HISTORY

A nearby drinking water pumping station (Navy Supply Well 2254-01, also known as the Red Hill Shaft) is located approximately 700 ft east of the OWDF and 2,600 ft makai (seaward) and topographically downgradient of the USTs (WP Supplement Figure 2). The pumping station, operated by Naval Facilities Engineering Systems Command (NAVFAC) Hawaii, Utilities and Energy Division, pumps groundwater from a horizontal water development tunnel (also known as an infiltration gallery) installed within the basal aquifer beneath Red Hill to the JBPHH water distribution system, which serves approximately 65,200 military customers with potable water. The water development tunnel extends from the pumping station approximately 1,200 ft east and southeast, away from the OWDF, to within 1,700 ft of Tank 1, the nearest RHSF UST. A groundwater sampling point (RHMW2254-01) is located within Red Hill Shaft to facilitate sampling. Detections of TPH quantitated as gasoline range organics (TPH-g), diesel range organics (TPH-d), residual range organics (TPH-o), volatile organic compounds (VOCs), and polynuclear aromatic hydrocarbons (PAHs) occurred occasionally at RHMW2254-01 during quarterly monitoring events between 2005 and 2020, but to date no COPC has been detected above the screening criteria at RHMW2254-01. Ethylbenzene, toluene, and total xylenes were detected once, at concentrations below the screening criteria, during the Fourth Quarter 2018 groundwater monitoring event, but were not detected during any previous or subsequent monthly quarterly sampling events.

As with all active groundwater supply wells, the operation of the Red Hill Shaft affects groundwater flow in its vicinity, as described below in Section 10.1.7.

10.1.1.3 RHSF DESCRIPTION AND HISTORY

The 20 RHSF USTs were constructed by the U.S. Government during 1940–1943 to support the Department of Defenses' efforts in the Pacific during and after World War II. The USTs remain instrumental today in maintaining operations throughout Hawaii and the Pacific. The USTs are located approximately 3,200 ft east and topographically upgradient of the OWDF (WP Supplement Figure 1). The tanks were constructed in two parallel rows of ten tanks, which are connected by short tunnels to the main upper and lower access tunnels that run roughly parallel to the Red Hill ridge. The main access tunnels contain light rail systems; fuel pipelines; and water, electrical, fire suppression, and air handling systems. In the lower access tunnel, short tunnels branch off from the main service tunnel to provide access to "face-walls" located at the base of each tank. Piping extends through each face-wall to fuel transmission lines that run from the RHSF to the OWDF and Pearl Harbor via the RHSF tunnel system.

The tanks are spaced approximately 200 ft on center and are separated from each other by 100 ft of basalt rock. Each tank has a capacity of approximately 12.5 million gallons. The bottoms of the tanks are approximately 123–151 ft msl, i.e., more than 100 ft above the basal aquifer in that area (DON 2016a). Originally, Tanks 3 through 20 contained Navy Special Fuel Oil (NSFO), and Tanks 1 and 2 stored diesel oil. Over time, each tank has been converted to store a variety of different fuel types, including Diesel Oil, NSFO, Navy Distillate, F-76, aviation gasoline (AVGAS), and motor vehicle gasoline (MOGAS) (DON 2002). Beginning in the early 1960s, the tanks were converted to also store the kerosene-based jet fuels Jet Fuel Propellant (JP)-5, JP-8, and F-24 (HAER 2015). According to Navy Region Hawaii, there is no intent to store MOGAS or AVGAS in the future. The active tanks now contain only JP-5, F-24, or F-76 Diesel Fuel Marine; two tanks (1 and 19) are inactive and out of service.

Red Hill Tank 5 2014 Release. In the course of refilling RHSF Tank 5 after scheduled maintenance, a release of JP-8 was discovered and verbally reported to the DOH on January 13, 2014. The release was confirmed and reported to DOH in writing on January 23, 2014. The volume of fuel released was estimated to be approximately 27,000 gallons. Because of this release, RHSF is currently subject to an Administrative Order on Consent (AOC) (EPA Region 9 and DOH 2015). The AOC, response actions, and the Navy's related groundwater LTM program for Red Hill are described in Section 10.1.10. Although the timelines and chemistry data do not appear to support the hypothesis, it has been suggested that impacts to the basal aquifer at the OWDF may be related to the Red Hill Tank 5 Release in 2014. The Site Assessment is designed, among other things, to evaluate this possibility.

10.1.2 Surrounding Area Land Use

The overall RHSF is zoned by the County as a mix of F1-Federal and Military and P-1 Restricted Preservation districts, and is bordered on the east and northeast by preservation lands; on the north by Halawa Correctional Facility, private businesses, including those in the Halawa Industrial Park, and the State of Hawaii Department of Agriculture Animal Quarantine Station; on the southwest by the U.S. Coast Guard reservation; on the south by residential neighborhoods; and on the southeast by Moanalua Valley. The Halawa Quarry is located less than a quarter mile away to the northwest.

The OWDF is bordered to the northwest by the State Animal Quarantine Station; to the north and east by portions of RHSF and Halawa Industrial Park; to the south by the toe of Red Hill ridge, portions of Coast Guard Housing, and Moanalua Freeway; and to the west by an open vegetated area.

10.1.3 Site Access

Access to the OWDF is from Halawa Valley Street, through Red Hill Main Gate, and via Icarus Way to the OWDF. A gate from the Coast Guard Housing leads to a former OWDF access road. This gate is opened only with written permission from the Coast Guard.

NAVSUP FLCPH personnel limit access to the OWDF. The OWDF is surrounded by chain-link fencing. The northwest perimeter of the OWDF bounds the channelized portion of South Halawa Stream. The stream is channelized by concrete and is fenced on both the OWDF side and the Animal Quarantine Station side. JBPHH Security personnel patrol nearby areas at least twice daily. The perimeter of the Coast Guard Housing adjoining the access road to the OWDF has two double chain-link fences separated by a steep, heavily wooded area.

10.1.4 Climate

The subtropical climate of Oahu is warm, humid, and dominated by the prevailing northeast trade winds and ocean currents. Ocean temperatures are approximately 75–85 degrees Fahrenheit (°F) at Honolulu, and air temperatures in Oahu average 70°–85°F, with the warmest months being June through October. Northeasterly winds persist most of the year, and the northeastern (windward) sides of the island are commonly the wettest due to orographic lifting and cooling of marine air, which increases precipitation. There are generally two seasons for precipitation on the island: October to April is considered the wet season, and May to September is considered the dry season. On the Ko‘olau Range’s leeward slopes, precipitation generally increases up-valley as elevation increases, and decreases down-valley. Average annual precipitation in upper North Halawa Valley and upper Moanalua Valley, at approximately 1,000 ft msl near the ridge line of the Ko‘olau Range, is approximately 139 and 137 inches, respectively (i.e., 0.4 inch per day) (USGS 2017c, b). In lower North Halawa Valley at approximately 180 ft msl, near municipal water supply well Halawa Shaft, formerly active precipitation gauges (2005–2009) recorded an average annual precipitation of 35-41 inches (i.e., 0.1 inch per day) (USGS 2017d, e).

10.1.5 Topography and Surface Water Drainage Patterns

This subsection describes the geomorphology, topography, and drainage of the OWDF site and the overall RHSF.

10.1.5.1 RHSF TOPOGRAPHY AND SURFACE WATER DRAINAGE PATTERNS

Four major geomorphic provinces define the island of Oahu: two volcanic mountain ranges (Waianae and Ko‘olau), the Schofield Plateau, and the coastal plains, which form the northwest and south margins of the island (Stearns and Vaksvik 1935). The Koʻolau volcano is a shield, or dome, volcano, the windward half of which collapsed due to catastrophic mass wasting (Walker 1990). The pali (cliff line) on the east side of the range defines the predominantly stream-eroded, back-collapsed scarp.

In the south-central part of the range, the leeward flank of the shield volcano is eroded into a series of parallel ridges and stream-carved valleys extending generally perpendicular from the Koʻolau crest. Red Hill is one such leeward ridge that descends 5 miles from the Koʻolau crest at approximately 2,200 ft msl southwest to the coastal plain. The surface elevation of Red Hill in the tank farm area is approximately 420–560 ft msl. The ridge's northwest and southeast flanks drop steeply to South Halawa Valley and Moanalua Valley, where valley floor elevations in the tank farm area are approximately 200 ft msl and 100–160 ft msl, respectively. North Halawa Valley lies north of South Halawa Valley and a low inter-valley ridge, which is the site of Halawa Quarry.

10.1.5.2 OWDF TOPOGRAPHY AND SURFACE WATER DRAINAGE PATTERNS

The OWDF is located within the RHSF boundary on the northwest-facing slope of the southern wall of South Halawa Valley at elevations ranging from 120 to 150 ft msl. The northwest perimeter of the OWDF is a short distance south of South Halawa Stream, which is concrete-lined and channelized for at least 4,200 ft into the valley, i.e., along and well mauka (inland) of the OWDF. The higher elevations between the southern perimeter of the OWDF and the Coast Guard Housing consist of steeply sloping land covered by scrub brush and low trees. The access road to the OWDF (Icarus Way) features an approximately 2–3 ft deep concrete drainage channel along the entire length of the road, which limits surface water running onto the OWDF.

The overall topography of the OWDF slopes generally north-northwest toward South Halawa Stream, with an overall elevation change of approximately 15–20 ft over a distance of approximately 200 ft, from east to west. The location of the former Two ASTs Area is the most elevated area within the confines of the OWDF, while the area near the now-abandoned RI monitoring well MW09 contains the topographic low point (WP Supplement Figure 2).

Observations made during RI field work suggested that run-on to and runoff from the OWDF is minimal. A system of large drainage ditches runs parallel to the access road along the more elevated perimeter of the OWDF. These drainage ditches divert offsite runoff from elevations above the OWDF to South Halawa Stream before it reaches the OWDF. On site, the portion of asphalt/concrete road and grassy area directly northwest of the OWDF (labeled "Site Runoff Area" on WP Supplement Figure 2) represents a localized topographic low. The Site Runoff Area was observed to be a collection and accumulation area for OWDF runoff during rainy periods (DON 2000).

10.1.6 Geology and Soils

The following section provides a description of both regional and site-specific geology and soils.

10.1.6.1 REGIONAL GEOLOGY AND SOILS

Basalt originating from the Koʻolau Volcanic Series lavas represents the bedrock and primary material for the basal aquifer beneath and around the OWDF. The units exposed in South Halawa Valley are flows of primarily aʻa lava of the Tertiary Koʻolau basalt (Izuka 1992). Aʻa flows typically consist of a relatively low-permeability central core, bounded by spiny, fragmented margins called "clinker." Spaces in the clinker margin of the aʻa flows allow efficient lateral transmission of basal groundwater, while the massive basalt cores inhibit vertical flow (Lau and Mink 1995). Fractures and vesicles throughout the entirety of most lava flows allow additional potential avenues for groundwater flow

(Stearns and Macdonald 1946). Localized portions of the basalt in South Halawa Valley are composed of thicker, massive aʻa flows, which inhibit the downward flow of groundwater. These massive flows commonly contain a significantly lower proportion of the fractures and vesicles than are characteristic of most other basalt formations in Hawaii. These massive basalt flows are the primary target of Halawa Valley quarries (Wentworth 1951). These qualities, which make the material suitable for mining and processing into cement and building material, may also make the massive flow material relatively impermeable to groundwater transmission.

Basalt material in the basal aquifer is overlain in some areas by tuffs and welded tuffs of the Honolulu Volcanic Series. The tuffs in the OWDF vicinity are formed by lithification of air-deposited volcanic ash originating from nearby Aliamanu, Salt Lake, and Makalapa Craters of the Honolulu Volcanic Series.

Sediments in Halawa and Moanalua Valleys are mainly alluvial. The older alluvium in some deep Oahu valleys is deposited in thicknesses of 100 ft or more above the bedrock basalt. In Halawa Valley near the OWDF, some of the alluvium has been transported and deposited by South Halawa Stream. Alluvium may also merge with underlying layers of saprolite (the product of heavily weathered basalt), blurring the boundary between substrata of volcanic and sedimentary origin. It has been observed that areas in Halawa Valley where basalt bedrock is overlain by alluvium and supplementing weathered bedrock represent zones of ineffective infiltration to the basal aquifer. Most of the rainfall percolating in these areas is typically absorbed into the younger overlying alluvial layers.

Although not observed during investigations of the OWDF or the RHSF, intrusive dikes have been observed in the general area (Izuka et al. 2016) and are often less than 10 ft wide, but can extend vertically and laterally for long distances. Dike complexes can form where individual dikes intersect at various angles. Dikes and dike complexes can intersect low-permeability, nearly horizontal lava flows, collectively inhibiting lateral and vertical groundwater flow and potentially resulting in high-level groundwater impoundments.

10.1.6.2 SITE GEOLOGY AND SOILS

Surface Soils. Generally, surface and near-surface soils consist of clay and rocky gravel (alluvium), due to the site location on the sideslope of a ridge above a valley eroded by a stream. Although the OWDF itself is classified in the literature as fill land (USDA SCS 1972), characterization of OWDF surface soil based on soil samples collected during the RI indicates that alluvium originating near the OWDF composes much of the surface and near-surface soil (DON 2000). The surface soils are composed primarily of larger sediments, mostly sands and gravels, which readily allow downward percolation of rainfall to the subsurface.

Geologic Cross Sections and Subsurface Geology. Cross sections of the OWDF based on previous investigations provide a framework for depicting the distribution of unconsolidated sediments, valley fill materials, Honolulu Volcanic Series tuffs, and Koʻolau basalts in and around the OWDF. These cross sections also relate hydrogeologic characteristics of the subsurface lithologies to their impact on fate and transport for the OWDF. Two cross sections were developed for the OWDF during the RI, using geologic information derived from borings (DON 1996a, 2000) and other observations during the Removal Action (DON 1996b):

- *Geologic Cross Section A–A′* (WP Supplement Figure 5) is oriented northwest to southeast, roughly perpendicular to the Red Hill ridge, following the local topographic contour. This section starts at former MW07 in the UPD area and traverses the Two ASTs Area, encompassing previous borings RHB04 (DON 1996a) and former well MW03 (DON 1996b) and ending at the location of existing monitoring well OWDFMW01 (formerly MW08). The cross section shows layers of sediment sloping and thickening from the higher elevation areas around OWDFMW01 toward the area closer to South Halawa Stream. The cross section reveals a corresponding transition from largely basalt bedrock in the upper region to increasing thicknesses of unconsolidated substrate with proximity to the stream. The section also illustrates the occurrence of low-permeability clay layers that appear to be extensive and continuous beneath the OWDF, thinning toward the southeast in the vicinity of the valley wall.

- *Geologic Cross Section B–B′* (WP Supplement Figure 6) is oriented roughly perpendicular to cross section A-A′ and runs from northeast to southwest, approximately parallel to the Red Hill ridgeline and toward the portion of the site perimeter that parallels South Halawa Stream. This section also starts at former MW07 in or near the UPD and Suspected Release areas; encompasses the locations of the abandoned former shallow well MW02 and abandoned former well MW09 and its test boring, which were located near the former Stilling Basin and Site Runoff Areas; and terminates at the boring drilled for MW06, which was located in the UDA but was not completed. The cross section confirms the presence of layers of increasingly thickening sediment in the area closer to South Halawa Stream, reaching up to 135 ft in thickness in the boring and test boring for MW09. This section also confirms the presence and continuity of multiple low-permeability clay layers throughout the subsurface beneath the OWDF and shows that the layers extend laterally beyond the perimeter of the OWDF.

Multiple clay-rich potential perching horizons were identified between ground surface and the basal aquifer during previous site investigations. Perched groundwater was encountered in all well borings advanced during the OWDF RI. The perched groundwater was contained within a weathered tuff layer occurring at depths of 26–36 ft below ground surface (bgs) (86–95 ft msl), which grades into a confining layer of weathered, dense clay between 30 and 40 ft bgs (82–91 ft msl) (DON 1996a). This uppermost clay layer formed the major perching horizon beneath the site. This clay layer was laterally extensive and appeared to continue beyond the borders of the OWDF, and samples from this zone demonstrated extremely low measured permeability. Below the uppermost confining layer, additional layers of interbedded low-permeability confining clays and clayey gravel extended vertically to the underlying basalt formation and laterally beyond the perimeter of the OWDF.

During drilling of the deep wells for the OWDF RI, a layer of “very dry” massive basalt was encountered to depths below zero ft msl in each of the three deep borings, confining the underlying regional basal aquifer, as described further below.

10.1.7 Groundwater Hydrogeology

The multiple low-permeability, clay-rich layers and associated perched groundwater zones beneath the OWDF observed during the RI (DON 1996a, 2000), as well as the massive basalt confining layer, likely represent significant potential hydrological barriers to downward transport of contaminants originating from the OWDF. The behavior of groundwater observed during the RI confirmed that the basal aquifer is locally confined by zones of massive basalt and additional low-permeability clay layers. The same low-permeability layers that induce locally confined conditions may act to protect the basal aquifer from downward transport of contaminants at the OWDF.

10.1.7.1 RED HILL REGIONAL HYDROGEOLOGY

Generally, groundwater in Hawaii exists in two principal aquifer types, basal and caprock; a third type, perched groundwater, also occurs in limited formations throughout the region, including at the OWDF:

- *Basal Aquifer:* The deeper basal aquifer exists as a lens of fresh water floating on and displacing seawater within the pore spaces, fractures, and voids of the basalt that forms the underlying mass of each Hawaiian island. Near the shoreline and at lower elevations within the coastal plains, groundwater in the basal aquifer is typically confined by the overlying caprock and is under pressure. Waters that flow freely to the surface from wells that tap the basal aquifer are referred to as artesian. Basal groundwater potentiometric elevations typically slope downward in the seaward direction. Thus, in the vicinity of Red Hill, the overall regional flow of basal groundwater is expected to be from higher mountain elevations (mauka) toward Pearl Harbor (makai). The potential exists for variances in the localized flow directions from the overall regional flow pattern; for example, weathered alluvial formations (such as "valley fill" material) can locally influence water movement by forming subsurface barriers along the axes and in the margins of valleys. These formations may impede lateral subsurface movement of basal water (Wentworth 1942) and may divert localized directions of groundwater flow from general regional trends.

  Basal groundwater elevations in the southern Oahu region range from 0 ft msl near the shoreline to elevations ranging between 20 and 30 ft msl in the vicinity of the southern Oahu Schofield water region boundary (USAF 2007; Nichols, Shade, and Hunt Jr. 1996). Regional basal aquifer groundwater ranges from unconfined to completely confined. Potentiometric heads in the Red Hill area vary between approximately 16 and 20 ft msl (WP Supplement Figure 7). In Halawa Valley, tuffs, stiff and fat clays, and gravely clays that compose valley fill sediments are relatively impermeable compared with most of the underlying bedrock basalt. Typically, basal water flowing makai through the basaltic aquifer is confined by thick sequences of low-conductivity sediments (caprock) that overlap the seaward-sloping margins of basal rock. Consequently, nearshore basal groundwater in Oahu is typically under artesian pressure.

  A specific exception to the general high-permeability nature of basal aquifer material is massive basalt, which is targeted for production at the nearby Halawa Quarry and was encountered during RI drilling in each basal borehole at the OWDF (DON 2000). Layers of this comparatively low-permeability material inhibit groundwater storage and transmission (Wentworth 1951). Thus, during drilling of the deep wells at the OWDF, a layer of massive basalt (dry to very dry in some areas) was encountered to depths below zero ft msl in each of the three deep borings. Other materials encountered near the groundwater surface included breccia. These materials caused locally confined conditions, inhibiting vertical flow, and indicating that there may be little to no hydraulic communication between the perched and basal aquifers beneath the OWDF (DON 2000). However, existing data is not conclusive and more information will be gathered in the proposed investigation to address data gaps, as described in this workplan.

- *Perched Groundwater:* Perched groundwater occurs when groundwater is isolated above the regional basal groundwater aquifer by a layer of low-permeability material (e.g., dense clays or lithified fine tuff). Perched groundwater in Hawaiian environments is typically limited in horizontal and vertical extent (Wentworth 1951). In addition to perched groundwater encountered throughout most of the OWDF during drilling for the RI (DON 1996a), shallow perched water-bearing zones have been reported at several locations in the Halawa-Red Hill-Moanalua area during well drilling or excavation activities, including at: Halawa Correctional Facility in South Halawa Valley (Dames & Moore 1991; EKNA 1999), City and County of Honolulu Halawa Bus Facility in North Halawa Valley (Kimura 2000), Tripler Hospital south of Moanalua Valley (ECC 2000), Red Hill monitoring well RHMW04 at approximately 183–228 ft msl (DON 2007), and Red Hill monitoring well RHMW08 in two different zones located at approximately 214–217 and 193–198 ft msl (DON 2017c). Shallow groundwater was also observed during the drilling of monitoring well RHMW11 on the South Halawa Valley floor at approximately 110–115 ft msl with continuous saturation within the saprolite (perched conditions not observed)

(DON 2018b). Similar but distinguishable conditions were observed during the drilling and installation of monitoring well RHMW14 on the South Halawa Valley floor at approximately 42 ft msl, with continuous saturation down to the basal aquifer (i.e., shallow groundwater was present but perched conditions were not observed) (DON 2019c).

- *Caprock Aquifer:* The coastal caprock aquifer consists of various kinds of unconfined and semi-confined groundwater. Commonly, the caprock consists of a thick sequence of nearly impermeable clays, coral, and basalt that separates the caprock aquifer from the basal aquifer. The impermeable nature of these materials and the artesian nature of the basal aquifer severely restrict the downward migration of groundwater from the upper caprock aquifer. The regional caprock aquifer is located downgradient of the OWDF and Red Hill Shaft, but may influence the regional flow of groundwater. Other subsurface barriers, such as volcanic tuff or other low-permeability units, might also affect regional groundwater flow.

State of Hawaii OWDF Aquifer Classification: DOH has adopted a regional aquifer classification by Mink and Lau (1990) to determine the permissible uses for groundwater in the different areas of Hawaii. This classification is used, among other things, to determine the environmental action levels (EALs) used for screening potential risk related to soil and groundwater contaminants detected at a site (DOH 2017). This use of aquifer classification criteria and groundwater designations is patterned after EPA Groundwater Protection guidelines (EPA 1988).

According to Mink and Lau (1990), the OWDF lies above an aquifer designated as the Waimalu System, part of the larger Pearl Harbor aquifer sector. Mink and Lau classify the region beneath the OWDF as an unconfined basal aquifer contained in horizontally extensive flank basalt lava flows of the Ko‘olau Range. This aquifer is given a Status Code of 11111, which indicates a fresh water source (i.e., with a chloride content below 250 milligrams per liter [mg/L]) that is a currently used, irreplaceable source of drinking-quality water that is highly vulnerable to contamination. The regional basal aquifer beneath the OWDF is included in the Oahu Sole Source Aquifer (also known as the Southern Oahu Basal Aquifer), designated a Sole Source Aquifer in 1987 under Section 1424(e) of the Safe Drinking Water Act (52 Fed. Reg. 45496). Sole Source Aquifers are those that are the sole or principal drinking water source for an area, and which, if contaminated and unmitigated, would create a significant hazard to public health. The Southern Oahu Basal Aquifer contains a host of extensive aquifer systems, including several located as far apart as Nanakuli, Wahiawa, Ewa Beach, and Honolulu.

Perched groundwater in and around the OWDF is not designated as a usable aquifer in the Mink and Lau classification system.

Regional Water Supply Wells: Two active municipal drinking water supply wells are located within a 1-mile radius of the OWDF (WP Supplement Figure 8). These wells are not true wells, but horizontal water supply shafts (i.e., water development tunnels or infiltration galleries) known in Hawaii as ‘Maui’-type shafts, from which water is pumped:

- *Navy Supply Well No. 2254-01* (Red Hill Shaft) is located in the RHSF tunnel system, approximately 700 ft east of the OWDF. The shaft’s horizontal water development tunnel extends through the basal aquifer under Red Hill approximately 1,200 ft east and southeast from the pumping station (i.e., away from the OWDF and to within 1,700 ft of the nearest USTs). Water quality is monitored on a regular basis from a sampling point (RHMW2254-01) in Red Hill Shaft for contaminants and general groundwater quality indicators. The measured concentrations of COPCs in RHMW2254-01 have not exceeded relevant regulatory limits in any of the LTM events.

- *Board of Water Supply (BWS) Halawa Shaft Well No. 2354-01* (Halawa Shaft) is located approximately 4,000 ft north of the OWDF in North Halawa Valley. The pumping station reportedly provides approximately 12 percent of the total municipal water supply on Oahu. Three other regional supply wells operated by BWS—the Moanalua Supply Wells 2153-10, 2153-11, and 2153-12—are located farther away from the OWDF, approximately 8,000 ft south-southeast of the OWDF in the Honolulu aquifer system (DON 2014). The Navy has not been informed of measured concentrations of petroleum-related COPCs ever having been detected or exceeding relevant regulatory limits in any of these BWS wells.

Regional Groundwater Levels and Flow Direction: Reviews of historical groundwater records indicate differences in basal groundwater elevations between the two primary aquifers of southern Oahu, the Honolulu and Pearl Harbor Aquifers (Wentworth 1951; Mink and Lau 1990). The Halawa Valley area represents the apparent boundary between the two systems. According to the boundaries delineated by Mink and Lau, the OWDF is in the Waimalu System of the Pearl Harbor Aquifer, just a short distance northwest of the boundary with the Moanalua system of the Honolulu aquifer sector. In general, the hydraulic head is higher in Moanalua than in Waimalu (Mink 1980), but groundwater flow between the Moanalua aquifer system and the Halawa region has not been definitively confirmed or delineated.

According to common reference sources, basal groundwater level elevations around the Halawa Valley area from 1980 through the present have ranged from approximately 14 to 18 ft msl, depending on rainfall conditions and water demand (Mink 1980). Based on typical behavior of groundwater in Hawaii, the expected overall regional direction of basal groundwater migration is seaward. For the Red Hill OWDF, the expected regional basal groundwater flow direction would be roughly westward, toward Aiea Bay, although the OWDF RI documented localized flow in the vicinity of the OWDF toward Red Hill Shaft during pumping conditions and rapid response (potentiometric drawdown and recovery) to changing pumping rates (DON 2000).

Based on the Mink and Lau scenario of an unconfined basal aquifer, borings penetrating to depths below 15 ft msl in the area of the OWDF should consistently encounter basal groundwater. However, none of the deep basal borings drilled in and around the OWDF during the RI encountered unconfined basal groundwater at that elevation. Rather, a thick layer of "very dry" massive basalt was encountered at these depths, which extended to depths *below* zero ft msl, at which point confined groundwater was encountered. After penetration of the massive basalt layer, potentiometric heads in the boreholes rose to the regional level of approximately 17 ft msl (DON 2000). Similarly, summary data regarding a set of geotechnical borings drilled by the State of Hawaii Department of Transportation (HDOT) in preparation for construction of the Interstate H-3 Freeway (HDOT 1988), presented in Table 10-1, show the presence of similar confining conditions. One HDOT boring drilled approximately 2,500 ft (0.5 mile) northwest of the OWDF was advanced to a depth equivalent of approximately 2.5 ft msl without encountering groundwater. Another boring drilled 2,000 ft (0.4 mile) west of the OWDF also did not encounter groundwater, despite being advanced to a total depth of -26.5 ft msl.

Table 10-1: Offsite Borings Drilled by HDOT within a 1-Mile Radius of the Red Hill OWDF

Boring	Completion Date	Listed Ground Elevation (ft msl)	Depth to Basalt (ft bgs)	Top of Basalt Elevation (ft msl)	Boring Total Depth (ft bgs)	Boring Total Depth Elevation (ft msl)
108-1A	08/09/1984	82	45	37	71.5	10.5
108-1D	08/09/1984	75	18	57	101.5	-26.5
108-04	08/07/1984	94	15	79	91.5	2.5

Continued:

Boring	Sediment Thickness (ft)	First DTW (estimated ft bgs)	Approximate DTW Elevation (ft msl)	Notes (bottom lithology)
108-1A	45	27	55	Clayey silt, stiff (old alluvium)
108-1D	18	none	none	Basalt gravel becoming more decomposed
108-04	15	none	none	Highly weathered basalt gravel, dense (old alluvium)

Source: State of Hawaii Department of Transportation. *Plans for Construction of a Portion of Interstate Route H-3.* Project No. I-H3-1 (54). September 1988 (HDOT 1988, reported in DON 2000).

bgs	below ground surface
DTW	depth to water
msl	mean sea level
none	groundwater not encountered

The localized variations in groundwater depth occurrences are indicators of locally confined basal groundwater conditions near the HDOT drilling locations. Overall, the evidence provided by the OWDF borings and the HDOT borings suggest that confined basal aquifer conditions occur throughout and beyond the OWDF boundaries.

10.1.7.2 OWDF HYDROGEOLOGY

A schematic model of the hydrogeologic setting for the OWDF, based on information gathered during the RI and other available sources, is presented on WP Supplement Figure 9, and the hydrogeologic setting is summarized below.

Perched Groundwater: A relatively shallow perched aquifer was encountered in almost all areas drilled during the OWDF RI (DON 1996a, 2000). The borings for the four perched water monitoring wells constructed along the perimeter of the Stilling Basin during Phase I field activities (MW02, 03, 04, and 05) encountered tuffs and stiff, fat clays that were relatively impermeable and formed one or more perching layer horizons. The tuff graded into weathered, dense clay layers between 30 and 40 ft bgs. Groundwater was not detected in a fifth shallow well, MW01, which was constructed during the 1991 Phase I field investigation (note that RI well MW01 is not the same as existing well OWDFMW01, which was referred to as MW08 during the RI). MW01, located approximately 90 ft south and topographically upgradient from the Stilling Basin, was intended as a background well and was constructed at the same depth ranges as the four other Phase I wells, but the boring encountered basalt rather than alluvium, and no confining layer was encountered upon which a perched water zone could form.

During the 1995 Removal Action (DON 1996b), original wells MW02 through MW05 were removed to enable demolition, excavation, and removal of the stilling basin and underlying soil, and perched groundwater was again encountered at similar depths in the four replacement shallow wells installed around the Stilling Basin perimeter (the replacement wells were also labelled MW02 through MW05). The perched groundwater was contained within a fractured tuff layer occurring at depths between 26 and 36 ft bgs. These observations are consistent with tuff layers documented in the Phase II RI deep boring logs of MW06, MW07, a test boring, and MW09 (DON 2000). The tuff appears to compose the perched water-bearing zone throughout much of the site, with the lower clay layers acting as confining layers; however, no free water was detected at those depths in MW06 or the test boring.

During drilling activities for the Phase II RI (DON 2000), multiple potential perching layers between the Stilling Basin and the basal aquifer were identified. Saturated depths of perched water measured during Phase II in each of the shallow wells installed in the perched groundwater zone varied widely. Intervals of perched groundwater approximately 10 ft deep were consistently observed in MW02 and MW03, located on the northwest and northeast boundary of the Stilling Basin, respectively (WP Supplement Figure 2). Observations made during perched water sampling showed that these two wells recovered quickly after purging. Prior to the Removal Action (DON 1996b), perched groundwater surfaces indicated a consistent downgradient slope to the north with gradient steepening toward the northeastern corner of the Stilling Basin (DON 1996a). By contrast, MW04 and MW05 consistently contained little or no water during Phase II sampling. MW05 contained sufficient water to sample during the Phase I RI, the Removal Action, and the Phase II RI first, but not second, sampling round. MW05 also demonstrated low rates of recovery during sample purging. MW04 contained sufficient water to sample only during the Phase I RI. The differences in water levels recorded for MW02 through MW05, the later lack of water in MW05 and MW04, and the lack of any perched water in MW01, the test boring, and the boring for MW06 suggest that the lateral extent and volume of perched groundwater beneath the OWDF during the Phase II RI was limited. This evidence that the perched zone beneath the OWDF was limited in extent is consistent with characteristics typical of perched groundwater in Hawaii and consistent with the State of Hawaii aquifer classification system characterization of the region, as Mink and Lau (1990) did not designate a perched groundwater aquifer for the region surrounding the OWDF. Although the extent of perched groundwater may be limited, the presence of low-permeability clay layers was consistently encountered throughout the site, and would be expected to impede downward flow.

Because the 1995 Removal Action changed the subsurface composition of the area directly beneath the Stilling Basin, the perched groundwater distribution and recharge patterns may have been altered. Additionally, after the excavation was backfilled, the Stilling Basin area was covered with a low-permeability liner as well as asphalt-concrete pavement. The cap and pavement were intended to significantly reduce the volume of water infiltrating to the perched groundwater zone beneath the Stilling Basin Area, in order to inhibit the downward flow of water and dissolved constituents that remained in the subsurface after the Removal Action (DON 1996b). Other construction for the 40,000-gallon AST, the access road adjoining the Stilling Basin, and the Two ASTs Area has also added asphalt-concrete pavement that further reduces the surface area available to allow infiltration to the subsurface beneath the OWDF. The gradual loss of water in wells MW04 and MW05 from the Phase I RI through the Phase II RI suggests that the cap was successfully limiting infiltration to the perched groundwater zone. The periods that samples were collected also suggest that seasonal rainfall fluctuation is not the factor controlling the loss of water. Perched groundwater sampling took place over several investigations over a 9-year period, and all rounds except for the second Phase II round took place during the wet season (December through March). The last perched water sampling was conducted 18 years ago; the current presence, nature, and extent of perched water at the OWDF are unknown.

During the Phase II RI, the zone between the perching horizons and the basal aquifer was observed to be very dry, indicating that little to no transport of perched groundwater to the basal aquifer was occurring. Observed behavior of the basal groundwater indicated that the basal aquifer beneath the OWDF was locally confined by overlying low-permeability (dry) massive basalt and saprolite. Regional information described above indicates that the locally confining conditions extend beyond the perimeters of the OWDF.

Stilling Basin Soil Hydrogeologic Properties and Hypothetical Leachate Estimates: Subsurface sediments observed at the OWDF during the RI were primarily fine-grained sediments. The 47 surface, trench, and boring soil samples collected for geotechnical analysis during the Phase I RI were dominated by clay, clayey sands, and clayey gravel. Grain size distribution analyses indicated 50 percent or more total clay-sized particles. The generally fine-grained sediments demonstrated low hydraulic conductivity (K) values, indicating low tendencies for allowing vertical groundwater transport.

Total organic carbon (TOC) content was measured in select RI soil samples collected from the Two ASTs Area, the UDA Area, and the UPD Area, providing a measure of the ability of soil to adsorb organic contaminants and inhibit contaminant mobility through the subsurface. TOC ranged from a minimum of 3,080 milligrams per kilogram (mg/kg) up to 21,300 mg/kg. The TOC values were used to conservatively estimate hypothetical leachate concentration in order to evaluate subsurface contaminant fate and transport at the OWDF, using benzo(a)pyrene and pyrene as indicator compounds. Results of estimated leachate concentrations, combined with observed hydrogeologic conditions and the basal groundwater analytical results, indicated that transport of detected soil PAH concentrations to the basal groundwater was unlikely and that the groundwater transport pathway was potentially complete but insignificant for benzo(a)pyrene and pyrene.

An additional overall estimate for the Stilling Basin leachate concentrations was made using data from confirmation soil samples collected during the Removal Action (benzo[a]pyrene but not pyrene was included in the confirmation sample analyses). Estimates were made using both a conservative low TOC content and the average TOC content. The estimated benzo(a)pyrene leachate concentration exceeded the EPA's initial screening level at the time (the Tap Water Preliminary Remediation Goal) only in the most conservative scenario, and both concentration estimates were well below the enforceable limit (the Maximum Contaminant Level). This provided further evidence that significant leachate impacts to the basal aquifer from the Stilling Basin leachate were not likely.

OWDF Basal Aquifer: Drilling conditions and groundwater behavior observed during installation of three basal aquifer monitoring wells installed during the Phase II RI indicated that the basal aquifer beneath the OWDF is locally confined. The basal groundwater elevation expected and measured in the region is approximately 14–17 ft msl (Mink 1980). Initially encountered depths to groundwater (120, 138.5, and 136 ft bgs, respectively) for MW06, MW08, and MW09 corresponded to respective elevations of -1.3, -2.8, and -20.3 ft msl. After release from confinement, groundwater potentiometric heads in these wells rose to the regional basal water elevation of approximately 17 ft msl. Appendix G contains the boring and well log for MW08, which is currently the sole existing onsite well (now referred to as OWDFMW01).

Continuous monitoring of the three basal aquifer monitoring wells was conducted from August 18 through October 6, 1998, during which time operation of the nearby Red Hill Shaft water supply pumps varied and was measured (WP Supplement Figure 10). Measured basal water levels in the OWDF basal aquifer wells ranged from 17.73 to 15.98 ft msl, correlating to the expected basal aquifer elevation for the area. Water levels in all three wells fluctuated in unison in relatively rapid response to pumping conditions. The plots show that drawdown at the pumping station was as much as approximately 6 ft when both pumps were on, and the differences in groundwater elevations between the three OWDF monitoring wells were generally less than 0.5 ft and remained fairly constant during different pumping conditions.

The basal aquifer wells were installed in a triangular pattern to allow basal groundwater flow direction beneath the OWDF to be estimated using simple triangulation. The anticipated overall regional direction of basal groundwater flow based on regional tendencies is seaward or roughly west of the OWDF, but local variations may be present. In the three OWDF basal wells, MW08 (now named OWDFMW01) consistently demonstrated the lowest basal groundwater elevation of the three wells, and simple triangulation of measured basal groundwater elevations in the three OWDF wells suggested that the basal aquifer groundwater gradient was oriented in easterly and northeasterly directions, roughly toward the nearby Red Hill Shaft during some events. The OWDF-specific basal groundwater flow direction appeared to be relatively consistent with time, at least while the Red Hill Shaft pumps were active, however, the study was relatively brief, included monitoring of only three onsite wells, and may reflect transient conditions from which final conclusions cannot be drawn. The calculated basal groundwater gradients (changes in measured basal aquifer elevation over distance between monitoring wells) ranged from 0.038 to 0.048 percent during the July to September 1998 period (DON 2000) (WP Supplement Figure 11). Thus, although simple triangulated gradient vectors varied in direction from pointing directly towards the Navy supply well located approximately to the east, to more north or northeasterly directions, it is not evident whether any gradient data free of the impact of pumping were recorded. It was concluded during the RI that the flow of basal groundwater beneath the site was strongly influenced by Red Hill Shaft. More information is required prior to drawing any conclusions, including better special resolution (to be provided by the new wells), better temporal resolution, and data gathered under more varieties of different transient and steady pumping conditions (to be automatically recorded and gathered over the course of a year).

Red Hill Shaft is located approximately 700 ft east of the OWDF and is connected to approximately 1,200 ft of water development tunnel (i.e., infiltration gallery). The pumping station is equipped with four pumps that cycle on and off to meet demand. According to Public Works Center personnel interviewed during the OWDF RI over 20 years ago, two pumps are typically kept in reserve, the station is pumped on a nearly continuous basis based on usage, and pumping is stopped only during early morning hours (P. Eyre, pers. comm. 1998; cited in DON [2000]). Water level plots measured in Red Hill Shaft show that the localized basal groundwater level lowers approximately 2–6 ft in response to pumping, depending on the number of pumps in operation. The plot of basal groundwater level measurements clearly illustrates:

- Decreasing potentiometric elevations (drawdown) with proximity to the pumping station
- Drawdown of the pumping station groundwater potentiometric elevations induced by pumping
- Successive drawdown in the wells with each pump coming on line
- Rise (recovery) of groundwater potentiometric elevations when pumps are turned off

Other factors that may influence localized groundwater flow direction include regional variations in geologic structure. For example, the existence of the large Aliamanu Crater south of the OWDF (WP Supplement Figure 1) may cause alterations or pose a partial barrier to direct seaward basal groundwater flow. Structural relationships between aquifers and confining layers may also affect the pattern of movement and entrapment of groundwater (Wentworth 1951). Directly beneath the OWDF, the effect of Red Hill Shaft pumping appears to counteract the expected regional basal groundwater flow, with MW08 (OWDFWM01) lying almost directly in the path of basal aquifer flow between the OWDF and the Red Hill Shaft water pumping station.

Therefore, based on the proximity of the water development tunnel, the pumping capacity, the hydraulic conductivity of the basal aquifer, and the observed groundwater potentiometric elevations at the OWDF during all pumping conditions evaluated, the OWDF probably lies within the zone of influence of the nearby Red Hill Shaft pumps. This Site Assessment is designed to further evaluate this relationship.

General Chemistry of the Perched Water and the Basal Aquifer. Analysis of groundwater samples collected during the two rounds of Phase II RI monitoring included analyses for general chemistry. Groundwater samples from the three basal wells, two of the perched wells, and Red Hill Shaft (RHMW2254-01) were analyzed for the eight major ions that normally compose more than 90 percent of the dissolved solids in groundwater (sodium [Na+], calcium [Ca2+], potassium [K+], magnesium [Mg2+], sulfate [SO42-], chloride [Cl-], bicarbonate [HCO3-], and carbonate [CO32-]) (Fetter 1994). This information allows for characterization of the chemical content of groundwater and the interaction of groundwater with aquifer materials.

The general chemistry differed between the perched groundwater and basal aquifer. Concentrations of the major anions chloride and sulfate and the major cations calcium, potassium, and sodium were higher in the basal aquifer than in perched groundwater (WP Supplement Figure 12). In addition, pH measurements indicate that the pH values were higher in the basal aquifer than in perched water. The RI attributed the high pH in basal water to basal rock and saprolite and the large amounts of grout pumped into the basal aquifer rock during Phase II well installation and borehole abandonment of MW07 and a test boring. It was also noted that total dissolved solids were elevated in MW08 (OWDFWM01). In addition, chloride in groundwater collected from well OWDFMW01 during the groundwater long term monitoring program has been significantly elevated from that measured in other area monitoring wells, well beyond what would be expected in this area. The extent of elevated chloride is a phenomena that will be further analyzed using the vastly expanded OWDF monitoring well network proposed in this investigation during the four quarterly groundwater monitoring events.

The major difference between perched groundwater and the basal aquifer beneath the OWDF was the composition of the water-bearing substrate. Comparison of water chemistry from different recharge environments typically indicates that potassium is much higher and bicarbonate is lower for groundwater in basalt-bearing rocks than in alluvial sediments (Miller 1961; Garrels and Mackenzie 1967; Kimball 1984). Potassium content is highest in unweathered rock relative to unconsolidated sediments, and the degree of potassium loss increases with degree of weathering from fresh rock to sediment (Goldich 1938). As a result, potassium concentration is much lower in clays and saprolite than in basalt rock (Krauskopf and Bird 1995). As described in Section 10.1.6.2, the water-bearing rock for perched groundwater at the OWDF is tuff or clayey gravel. The water-bearing rock for the basal aquifer is typically vesicular basalt except for former MW09, which was characterized as clayey gravel interbedded with basalt.

10.1.8 Vegetation and Wildlife

A biological field survey of the Red Hill OWDF and surrounding habitats was conducted as part of the Phase I RI (DON 1996a). The survey indicated that no native or sensitive species were observed or expected to occur at or adjacent to the OWDF, primarily because of a lack of appropriate habitat. The aboveground portion of RHSF is inhabited by non-native vegetation, including scrub, disturbed habitat, and landscaped areas. The scrub community on Red Hill is dominated by koa haole (*Leucaena leucocephala*), as well as guinea grass (*Panicum maximum*) and Chinese violet (*Asystasia gangetica*). Koa haole grows throughout Oahu, primarily in areas that have been disturbed by grazing or human activities. The disturbed habitat is composed of weedy plant species that can withstand frequent disturbance by human activities or natural events. Although this vegetation does support some wildlife species, the habitat is considered very low quality and is primarily used by introduced, common urban species. Halawa Stream flows by the OWDF, but is channelized within concrete and does not support sensitive habitat. Thus, the habitat at and around the OWDF is not considered sensitive and is dominated by introduced plant and animal species that have replaced native species.

Nevertheless, because the endangered Hawaiian hoary bat (*Lasiurus cinereus semotus*) can conceivably use trees almost anywhere on Oahu, including at the OWDF site, field personnel will coordinate with the Navy's Natural and Cultural Resources personnel to obtain guidance and clearance prior to mobilization.

10.1.9 Previous Investigations and Removal Action

Site investigations at the OWDF began after a 1983 *Initial Assessment Study* (NEESA 1983) identified the area as one that potentially posed a threat to human health or the environment. Red Hill (with primary focus on the OWDF) was one of 18 geographic study areas included in the Pearl Harbor Naval Complex National Priorities List site in October 1992 (EPA ID: HI4170090076). Following preliminary investigations, a RI and Removal Action were conducted, and the site received NFA status from the DOH in 2005.

Following is a summary of relevant environmental investigations and the Removal Action completed at the OWDF:

- *Initial Assessment Study of Pearl Harbor Naval Base* (NEESA 1983)*:* The Initial Assessment Study identified and assessed various sites potentially posing a threat to human health or the environment due to contamination from past hazardous materials operations at Pearl Harbor Naval Base (now incorporated into JBPHH). The study recommended the Red Hill Oily Waste Disposal Pit for a confirmation study involving a hydrogeologic evaluation to establish local groundwater flow direction and determine optimum well locations, subsurface soil and groundwater sampling at four monitoring wells, and quarterly monitoring of the wells.
- *Physical, Chemical, and Toxicological Characteristics of Oily Sludges Generated at Naval Installations* (Rockwell International 1983)*:* Conducted while the Stilling Basin was still in operation, this investigation characterized oily sludges generated by various Navy installations, including collection and analysis of two samples each from the Stilling Basin's pit-bottom sludge and light nonaqueous-phase liquid (LNAPL) oil from the surface. The report concluded that the principal contributors to oily sludge toxicity were PAHs, phenols, and heavy metals.
- *Verification Phase Confirmation Study, Site 6 - NSC Pearl Harbor Red Hill Oily Waste Disposal Pit* (DON 1988)*:* Following up on the recommendations in the Initial Assessment Study, this subsurface investigation confirmed elevated concentrations of petroleum hydrocarbons and semivolatile organic compounds (SVOCs) in four soil test borings advanced to depths up to approximately 42 ft bgs near the Stilling Basin. Boring logs indicated stiff to very stiff sandy, clayey, or silty material in most of the borings, with basalt at depth in some of the borings. One grab groundwater sample was collected from a temporary monitoring well placed within the only borehole that encountered (perched) groundwater. The groundwater sample contained low levels of toluene and PAHs, plus barium, which was concluded to be at background levels. The report recommended further characterizations to determine the vertical and lateral extent of petroleum hydrocarbon contamination in area soil and basal groundwater, including in a vegetated depression west of the disposal pit (later termed the UDA) where sludge from the pit was reportedly pumped.

- *Phase I Remedial Investigation* (DON 1996a)*:* The Phase I RI commenced in 1991 and included identification of several potential EAOCs where the potential for historical releases, discharges, or dumping was observed, reported, or inferred (WP Supplement Figure 2). The field investigation sampled surface and subsurface soil, the Stilling Basin contents (residual liquid and sludge), and perched groundwater collected from four shallow monitoring wells installed around the perimeter of the Stilling Basin. The samples were analyzed for various combinations of volatile organic compounds (VOCs) (including aromatic and halogenated VOCs), SVOCs, PAHs, phenols, TPH, total fuel hydrocarbons, organochlorine pesticides, polychlorinated biphenyls (PCBs), and metals (including organic lead). Sludge samples were analyzed for the same analytes plus Toxicity Characteristic Leachate Procedure extraction and analysis for disposal characterization. Analytical results suggested that only petroleum-related hydrocarbons significantly impacted the OWDF, with the main source being the Stilling Basin (in addition, localized concentrations detected at the Two ASTs Area, the UPD system, and the UDA reportedly presented potential human health risks; however, this was later discounted based on the Phase II RI findings). Air and surface water runoff exposure pathways were found to be potentially complete but insignificant, and no significant ecological risks were expected due to the absence of sensitive receptors. The Phase I RI report recommended: continued monitoring of perched groundwater at the Stilling Basin monitoring wells; further characterization of the Two ASTs Area, the UPD system, and the UDA; further investigation to evaluate the potential connection between the perched groundwater-bearing zone detected immediately beneath the OWDF and the underlying basal aquifer; and investigation of potential impacts to the basal groundwater from the petroleum hydrocarbons detected at the OWDF.
- *Removal Action* (DON 1996b)*:* Based on the Phase I RI results and recommendations resulting from an Engineering Evaluation/Cost Analysis (DON 1994), a Removal Action was conducted to remove the Stilling Basin (which was identified as the primary source of contamination at the OWDF) along with underlying and nearby contaminated soil (which was identified as posing the primary potential threat to groundwater). The Stilling Basin's contents, liner, and most of the UPD system were removed and disposed of (the remainder of the UPD piping was grouted, capped, and abandoned in place). Approximately 20 ft of underlying petroleum hydrocarbon-impacted soil was excavated (although not to the deepest depth of petroleum contamination detected during the Phase I RI), treated off site by thermal desorption, and returned to the excavation along with clean imported soil as fill. A low-permeability geosynthetic and pavement composite cap was installed over the area to reduce infiltration and the potential for contaminant transport. Following site restoration, the four perched groundwater monitoring wells located around the perimeter of the Stilling Basin, which were abandoned prior to commencing excavation, were replaced with four new wells bearing the same identifiers, MW-02 through MW-05. Although detected concentrations of TPH in several Removal Action confirmation soil samples collected at the base of the excavation exceeded the screening criteria, because individual COPC compounds (VOCs, PAHs, PCBs, lead, and cadmium) either were not detected or did not exceed the cleanup criteria, the removal and treatment of the Stilling Basin were concluded to be successful in mitigating identified risk.
- *Phase II Remedial Investigation* (DON 2000)*:* The Phase II RI commenced in 1998 and investigated the three EAOCs recommended by the Phase I RI for further characterization, the potential connection between the perched groundwater and the basal aquifer beneath the OWDF, and the potential impact of COPCs detected in the perched groundwater on the basal aquifer. Four relatively deep borings were drilled (MW06, MW07, MW08, and MW09). Three of these borings (MW06, MW08, and MW09) were successfully converted to basal aquifer

monitoring wells (MW07 was abandoned when elevated groundwater levels persisted despite continued bailing, which reportedly indicated the inflow of perched water into the well and lack of penetration into the basal aquifer). Surface and subsurface soil sampling and two rounds of perched and basal groundwater sampling were conducted. Soil and groundwater samples were analyzed for TPH and PAHs, and groundwater samples were also analyzed for VOCs and general chemistry parameters.

Elevated TPH concentrations were found sporadically in some of the surface and subsurface soil samples. Benzo(a)pyrene was detected at elevated levels in surface soil samples from two of the three EAOCs. In perched groundwater samples, low levels of TPH and pyrene were found in one well during the first round of sampling, and very low levels of TPH were found in two wells during the second round. In basal groundwater samples, no COPCs were detected in either sampling event (except for low-level detections of acetone and chloroform in some basal groundwater samples, which were attributed to laboratory contamination due to the lack of an identifiable source and lack of detection in source media samples). As described in Section 10.1.7.2, multiple low-permeability clay layers were observed in the soil borings advanced for the basal groundwater wells, and the basal aquifer below the OWDF was found to be confined below elevations expected for the region. Hydrogeologic monitoring and characterization indicated that the basal groundwater demonstrated a general flow direction east toward nearby Red Hill Shaft.

The Phase II RI concluded that the site did not pose a threat to human health or the environment, and that any potential transport of contaminants from past site operations to the basal aquifer were (and were likely to remain) insignificant due to the 1995 Removal Action, lack of impacts to the drinking water aquifer, reduction of infiltration due to the composite cap, and observed major hydrogeologic barriers during installation of basal groundwater monitoring wells at the site. The Red Hill OWDF site was recommended for NFA under CERCLA and was thereafter regulated under state law as a petroleum site due to TPH detections in soil and perched groundwater, with oversight by the State of Hawaii (DON 2001a).

- *8,000-Gallon AST Area Total Petroleum Hydrocarbon-Diesel Characterization Report* (DON 2003): In 2002, additional field investigation was conducted at the Two ASTs Area (the ASTs were removed in 1999) to further characterize the extent of TPH-d in a localized subsurface area where concentrations exceeded DOH action levels in Phase II RI soil samples. The study found that the elevated concentrations occurred in isolated discrete locations, and the geotechnical and soil texture data indicated little or no potential for downward migration, supporting the conclusions reached during the Phase II RI. The Red Hill OWDF site was recommended for NFA, and in 2005 DOH concurred (DOH 2005).
- *Well Abandonment Technical Memorandum* (DON 2006)*:* In 2006, after the site received the NFA determination, all remaining perched and basal monitoring wells at the OWDF except basal well MW08 were abandoned. As discussed below, MW08 was later renamed OWDFMW01 and incorporated into the Red Hill groundwater LTM program set forth in the *Red Hill Groundwater Protection Plan* (DON 2008, 2014).

10.1.10 Ongoing AOC Investigation and Red Hill Groundwater Long-Term Monitoring

As noted in Section 10.1.1, the RHSF is currently being investigated pursuant to the Red Hill AOC (EPA Region 9 and DOH 2015), and the basal groundwater beneath and around Red Hill is undergoing long-term groundwater monitoring, which includes sampling of OWDFMW01. These ongoing investigations at Red Hill include investigation and remediation of contamination, modeling of regional groundwater flow and contaminant fate and transport, and expansion and monitoring of the groundwater monitoring well network. These investigations have provided and continue to provide a better understanding (since the time of the 1990s OWDF RI) of the geological features of the Red Hill area and other factors that influence flow and quality of groundwater in the general vicinity of the OWDF. Pertinent data collected from the regional aquifer pertain to COPCs, ionic chemistry, and natural attenuation parameters (NAPs), which are summarized in this subsection.

10.1.10.1 COPCS IN THE RED HILL MONITORING WELL NETWORK

Pursuant to the Red Hill *Groundwater Protection Plan* (DON 2014), the Navy conducts basal groundwater monitoring events quarterly at a minimum at the Red Hill Shaft sampling point (RHMW2254-01) and 15 other monitoring wells in and around Red Hill, including OWDFMW01 (WP Supplement Figure 8). All Red Hill network monitoring wells except OWDFMW01 were installed after the OWDF RI was completed, and installation of additional monitoring wells by the AOC investigation is ongoing. In accordance with the AOC investigation's scoping completion letter (EPA Region 9 and DOH 2016) and the AOC Statement of Work Sections 6 and 7 *Sampling and Analysis Plan* and addenda (DON 2017d, f, 2018c), the groundwater samples are currently analyzed for:

- Select petroleum-related analytes (TPH-g; TPH-d; TPH-o; benzene, toluene, ethylbenzene, and xylenes; 1-methylnaphthalene; 2-methylnaphthalene; and naphthalene)
- Lead scavengers (1,2-dibromoethane and 1,2-dichloroethane) for newly installed monitoring wells only (these are consistently not detected and then subsequently dropped from the analyte list)
- Fuel additives (2-[2-methoxyethoxy]ethanol and phenol)
- NAPs (methane, dissolved oxygen, oxidation-reduction potential, ferrous iron, sulfate, nitrate, chloride, nitrate-nitrite as nitrogen, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, TOC, dissolved organic carbon, and TPH with silica gel cleanup [SGC])
- General chemistry parameters (bromide, fluoride, total silica, dissolved silica, total calcium, total magnesium, total manganese, total potassium, and total sodium)

The COPC data are compared to DOH EALs for groundwater (that is a current or potential drinking water resource and where a surface water body is not located within 150 meters of the release site[1]). For three of the wells located near the USTs (RHMW01, RHMW02, and RHMW03), the TPH-d and benzene concentrations are also compared to site-specific risk-based levels (SSRBLs) that were developed for the Red Hill *Groundwater Protection Plan* by modeling the fate and transport of petroleum hydrocarbons in groundwater between RHSF and the closest water supply well (Red Hill Shaft) (DON 2014). The results of each monitoring event are reported to DOH, and COPC trends are subject to close scrutiny by the AOC Parties (Navy; DLA; EPA Region 9 Underground Storage Tank Program, Land Division; and DOH Solid and Hazardous Waste Branch and Safe Drinking Water Branch) and other interested entities. Overall COPC trends indicate that petroleum-related impacts were primarily seen at RHMW02 (see WP Supplement Figure 13, which plots TPH-d concentrations over time at OWDFMW01 and select nearby monitoring locations sampled in the LTM program). At OWDFMW01, there have been sporadic detections of TPH-d at concentrations exceeding the EAL, and a few other analytes were occasionally

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[1] Although several wells (including OWDFMW01) in the Red Hill groundwater monitoring network are located within 150 meters of surface water (i.e., South Halawa Stream), the >150-meter EALs are used for screening by the Red Hill LTM program because there are no indications of any complete pathways from the tank area to receptors associated with a surface water pathway. (In addition, South Halawa Stream is an intermittent stream [USGS 2017a], and the stream channel in the vicinity of most of these wells is concrete-lined.)

detected at trace concentrations (WP Supplement Figure 14). The data also show that seasonal variations and Red Hill Shaft pumping conditions have little or no effect on groundwater COPC (and NAP) concentrations. Appendix D contains a table of cumulative historical groundwater results for detections in OWDFMW01 samples collected during the LTM program.

The recent Red Hill *Fourth Quarter 2019 – Quarterly Groundwater Monitoring Report* (DON 2020) summarized the latest analytical results as follows:

- *OWDFMW01, RHMW2254-01 (primary and duplicate), RHMW01, RHMW04, RHMW05, RHMW06, RHMW07, RHMW08, RHMW09, RHMW10, RHMW11-05, RHMW11-07, RHMW14-01, RHMW14-02, RHMW14-03 (primary and duplicate), RHMW14-04, RHMW14-05, RHMW14-07, RHMW15-01, RHMW15-02, RHMW15-03, RHMW15-04, RHMW15-05 (primary and duplicate), and HDMW2253-03:* No COPCs were detected.
- *RHMW02 (primary and duplicate):* TPH-d (1,700 and 1,800 µg/L), 1-methylnaphthalene (30 and 31 µg/L), 2-methylnaphthalene (26 and 27 µg/L), and naphthalene (66 and 68 µg/L) were detected at concentrations exceeding the respective screening criteria (400, 10, 10, and 17 µg/L). TPH-d was also detected in the SGC analysis, but at significantly lower concentrations (520 and 430 µg/L), suggesting that the majority of the non-SGC TPH-d results are biodegradation by-products. The concentrations of TPH-d did not exceed the SSRBL of 4,500 µg/L. TPH-gasoline range organics (81 and 74 µg/L) and TPH-residual range organics (TPH-o) (200 and 190 µg/L) were detected at concentrations below the respective screening criteria (300 and 500 µg/L).
- *RHMW03:* TPH-d (150 µg/L) and TPH-o (230 µg/L) were detected at concentrations below the respective screening criteria (400 and 500 µg/L). The TPH-d and TPH-o with SGC analysis results were non-detect, suggesting that the non-SGC TPH-d result consists entirely of biodegradation by-products.

The sporadic incidences of elevated concentrations of TPH-d in OWDFMW01 do not correlate well with increases in other area wells (such as those near the tank farm), and therefore are unlikely to be attributed to the releases from the RHSF USTs (WP Supplement Figure 13). Interpretation of the data is complicated by the fact that laboratory results reported as "TPH" do not measure a specific compound, but instead the reported results are capable of capturing a host of compounds, depending upon the specific laboratory method used. Thus, "TPH-d" results do not necessarily quantify compounds that derive from diesel fuel, despite the name of the test method (Zemo, O'Reilly, et al. 2013). For example, if the analytical method used by the laboratory is altered (such as by using different extraction solvents, extraction methods, or calibration standards, or reporting different carbon ranges), the analytical results reported as "TPH-d" will also differ. Here, the different laboratories used over the course of the LTM program employed different analytical methods, which accounts for some of the apparent variability in "TPH-d" results. For these and other related reasons, the DOH TGM states that a detailed review of the chromatographic pattern and site history is necessary to properly interpret TPH results (DOH 2018). Thus, the constituents reported as "TPH-d" in groundwater near the RHSF are not necessarily the same constituents that constitute the "TPH-d" detected at the OWDF. To the contrary, chromatograms from the Red Hill LTM program generated for the detection of elevated "TPH-d" in OWDFMW01 in July 2015 do not resemble the chromatograms from RHMW01, RHMW02, or the laboratory control sample, all of which have characteristic petroleum "humps," unlike OWDFMW01 (WP Supplement Figure 15). The chromatograms suggest that the Third Quarter 2015 reported impacts to groundwater beneath the OWDF did not originate from the 2014 RHSF release; this investigation has been designed in part to further evaluate this possibility.

10.1.10.2 NATURAL ATTENUATION PARAMETERS IN THE RED HILL MONITORING WELL NETWORK

In addition to the target COPCs, RHSF groundwater samples are analyzed for the following NAPs: methane, ferrous iron, nitrate, sulfate, chloride, nitrate-nitrite as nitrogen, alkalinity (carbonate, bicarbonate, and total), dissolved oxygen (DO), oxidation-reduction potential (ORP), and TPH with SGC. The reported NAP concentrations at RHMW01, RHMW02, and RHMW03 (located near or within the tank farm), including depleted DO, the presence of dissolved methane, relatively high concentrations of other electron acceptors, and the measured generation of heat and carbon dioxide, provide several lines of evidence that aerobic or anaerobic biodegradation may be occurring at these locations. This conclusion is bolstered by the SGC TPH results, which present a relatively low ratio of non-biodegraded (non-polar) hydrocarbons to biodegradation by-product hydrocarbons (polar hydrocarbons and metabolites). Methane concentrations at RHMW01 and RHMW02 have generally decreased over time, which may be an indicator of reduced available biodegradable fuel at the subsurface from various natural source-zone depletion processes and natural attenuation. Although no similar indications of ongoing natural attenuation were evident at OWDFMW01 or any of the other area monitoring wells located away from the tank farm (suggesting that degradable petroleum hydrocarbons are limited to the vicinity of the RHSF USTs, and that impacted groundwater from the vicinity of the USTs is probably not a source of hydrocarbons at the OWDF), the proposed investigation will further evaluate this possibility for the OWDF.

10.1.10.3 IONIC CHEMISTRY OF THE RED HILL MONITORING WELL NETWORK

Groundwater major ion chemistry analysis was conducted in several monitoring events conducted from November 2016 through Fourth Quarter 2019, as new monitoring wells were installed. These data provide general information regarding the non-COPC chemical content of groundwater, and may provide insight into the interaction of groundwater with aquifer media and the source of groundwater. The major ion composition of the groundwater is summarized on WP Supplement Figure 12, which is a trilinear diagram known as a Piper diagram that displays the distribution of the relative concentrations of major cations and anions. The Piper diagram includes a cation ternary plot (calcium, magnesium, sodium plus potassium) on the lower left, and an anion ternary plot (sulfate, chloride, and carbonate plus hydrogen carbonate) on the lower right. The upper diamond-shaped plot summarizes the dominant cations and anions distribution that could be used to classify the type of groundwater. The Piper diagram facilitates visual comparison of the major ion composition in water samples that may reflect the effects of recharge, aquifer interactions, and chemical sources on groundwater. Each data point on the trilinear plot shows the composition of the water sample as a percentage of total ions, in milliequivalents per liter (meq/L). A plot of several samples from different locations in a study area is often useful to identify mixtures of different water types (Hem 1985). Mixing of two distinct water types is seen as a linear trend in the data points.

Here, although all the Red Hill monitoring wells are located within the same large basal aquifer, the presence of multiple water types suggests that varying processes may be occurring in various locations in the groundwater system. Groundwater composition is generally controlled by weathering, mineral dissolution, cation exchange, and inverse cation exchange processes (Kumar 2013). RHMW01, RHMW02, and RHMW03 are located near the RHSF USTs and can be characterized as belonging to the sodium bicarbonate groundwater type; this region of the groundwater region is primarily influenced by hydrocarbon biodegradation within the basaltic bedrock. OWDFMW01, RHMW2254-01, and RHMW07 can be characterized as belonging to the calcium magnesium sulfate chloride groundwater type. These wells are located closer to the valley and South Halawa Stream, and might be influenced by alluvium. Other well locations have groundwater that can be characterized as the sodium chloride sulfate water type; most of these monitoring wells are farther from the stream and USTs, and may exhibit more complex and mixed conditions.

One of the most meaningful geochemical parameters in groundwater is chloride because it is less reactive than other major ions with the crystalline rock, sediment, and soils through which groundwater moves, and is relatively unaffected by bacterial reactions and biodegradation processes. As shown in the cumulative NAP charts in the latest Red Hill quarterly groundwater monitoring report (DON 2019b, Appendix A.3.1), samples from wells nearest the RHSF USTs show the lowest chloride concentrations, which range from 37 to 47 mg/L in RHMW02, RHMW01, and RHMW03. By contrast, OWDFMW01 has consistently had by far the highest chloride concentration (approximately 1,000 milligrams per liter [mg/L]) of all the wells screened near the basal aquifer surface throughout the duration of the LTM program. Similarly high chloride concentrations in the wells being monitored are only found in the deep samples collected at HDMW2253-03, which was installed by the State of Hawaii Department of Land and Natural Resources to monitor the aquifer's freshwater-saltwater interface: for example, a sample collected in November, 2006 at a depth of 624 ft bgs had a reported concentration of 1,874 mg/L, whereas the shallow sample from the same well collected at a depth of 50 ft bgs contained chloride at a concentration of only 88 mg/L; by comparison, the sample from Red Hill Shaft (RHMW2254-01) contained chloride at 72.3 mg/L (DON 2019a). Comparable data from the OWDF shallow perched monitoring wells could have informed this analysis but were not collected during the OWDF RI, after which all the OWDF perched wells were abandoned.

It has also been noted that pH levels were elevated in OWDFMW01 compared to the other wells in the RHSF LTM well network. This will be further analyzed in the new wells during the proposed Site Assessment.

10.1.11 Site Reconnaissance Findings

A site reconnaissance was conducted for the development of this WP on November 8, 2019. Conditions remained similar to those reported during the RI (WP Supplement Figure 2). Overall, the site primarily consists of haole koa (*Leucaena leucocephala*) scrub and disturbed habitat near facility infrastructure. South Halawa Stream flows west in a concrete-lined channel north of the site. An 8-ft-high chain-link fence with barbed wire lines both sides of Icarus Way in the vicinity of the OWDF, and a drainage canal traverses the uphill side of Icarus Way. The developed portions of the site are surrounded by chain-link fencing, and both AST no. 311 and the cap over the former disposal pit appear to be in essentially the same conditions and locations as reported during the RI. Two new ASTs, constructed 2–3 years ago as part of the RHSF's new aqueous film-forming foam fire suppression system, were observed at the site: one located west of the former Stilling Basin and the other, AST no. D-24, located a short distance northwest of OWDFMW01. According to the Navy, the former AST is a backup holding tank that does not normally contain any fluids. Most of the fencing that surrounded the former disposal pit has been removed, and the area did not appear to be in-use other than for access to the nearby ASTs.

One of the seven proposed well clusters is located outside of the OWDF perimeter fencing, but still on Navy property. Proposed Well Cluster OWDFMW04, which is discussed in more detail below, is located upslope of the OWDF at the toe of Red Hill, in a fenced area densely vegetated by haole koa and guinea grass (*Panicum maximum*) (WP Supplement Figure 16). The nearest existing access gates in this area are located at lower Icarus Way approximately 650 ft east of the OWDF access road, and at upper Icarus Way approximately 400 ft directly south of the OWDF access road (1,450 ft by road). The elevation at this location is approximately 20 ft higher than the elevation of lower Icarus Way at the OWDF entrance.

10.2 SOURCE, RECEPTOR, AND EXPOSURE ASSESSMENT

The Phase II RI presented the human health and ecological receptor exposure assessment in light of the Removal Action and all of the data gathered during the two-phase RI (DON 2000). The former Stilling Basin, associated piping, and underlying impacted soil were removed in the mid-1990s as part of the Removal Action, which also included backfilling the excavated area with remediated and clean imported soil and lining the area with a low-permeability cap that was covered with asphalt (DON 1996b). Upon completion of the removal action and the two-phase RI, human consumption of basal groundwater was found to be the only potentially complete exposure pathway with the potential for appreciable risk, because the aquifer is a source of drinking water for humans. The 2005 NFA determination thus rested primarily upon the lack of impacts to the basal groundwater at the time and analyses that suggested future impacts were not likely. Due to this result, and because this investigation is being conducted to evaluate the detection of elevated levels of TPH in groundwater in the 2010-2015 timeframe, this Site Assessment focuses on the basal groundwater pathway.

The RI concluded that the primary source of contaminants at the site is historical petroleum contamination originating from the former Stilling Basin and Disposal Pit (WP Supplement Figure 9). While this may remain true, analyses of the RHSF LTM data and investigations performed pursuant to the AOC also could be interpreted to suggest a potential link between groundwater beneath the OWDF and groundwater beneath Halawa Industrial Park or groundwater in the vicinity of the RHSF USTs. No data have been identified regarding groundwater quality in the vicinity of Halawa Industrial Park. However, extensive data are available for the RHSF, and, because the TPH chromatograms from OWDF do not resemble those from RHSF (WP Supplement Figure 15) and the temporal patterns of detections at the two facilities do not align (WP Supplement Figure 12), the source of "TPH" at the OWDF might not be fuel release(s) from the RHSF USTs. This Site Assessment is intended to further evaluate these possibilities. Thus, in addition to former onsite operations, other potential offsite sources of constituents that could be reported as TPH could conceivably include the RHSF USTs, facilities within the Halawa Industrial Park, and other sources potentially transported via South Halawa Stream. The proposed groundwater monitoring well clusters described in Worksheet #14 are intended to investigate these possibilities.

Based on the reported presence of TPH in basal groundwater, potential site COPCs (and corresponding test methods) include the following:

- TPH-d and TPH-o [EPA 8015], including re-analysis using silica gel cleanup to remove the polar fraction of TPH for those samples with detectable concentrations of TPH-d and TPH-o
- TPH-g [EPA 8260 or EPA 8015]
- VOCs (which will be analyzed along with Tentatively Identified Compounds [TICs]) [EPA 8260]
- SVOCs (which will also be analyzed along with TICs) [EPA 8270]
- PAHs [EPA 8270 SIM]
- Dioxins and furans [EPA 8290]

The following groundwater NAPs and other parameters will also be analyzed along with the COPCs:

- Dissolved oxygen [field parameter]
- Oxidation-reduction potential [field parameter]

- pH [field parameter]
- Methane [RSK 175]
- TPH-d; TPH-o with SGC [EPA 3630/8015]
- Total and dissolved organic carbon [EPA 9060]
- Nitrate, sulfate [EPA 300.0]
- Nitrate-nitrite as nitrogen [EPA 353.2]
- Ferrous iron [SM3500-FeB]
- Alkalinity (total, bicarbonate, carbonate) [SM2320B]

Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements

This worksheet documents the project quality objectives (PQOs) developed for the proposed Site Assessment in accordance with Steps 1 through 7 of the United States Environmental Protection Agency (EPA) 7-Step Data Quality Objectives (DQOs) process, as defined in *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (EPA 2006), and NAVFAC Project Procedure I-A-1, *Development of Project Quality Objectives*. The seven-step process is an evaluation tool used to identify the problems, goals of the study, and steps required to make appropriate decisions.

11.1 STEP 1: STATE THE PROBLEM

Following the State of Hawaii Department of Health's (DOH's) no further action (NFA) determination for the Oily Waste Disposal Facility (OWDF) in 2005, all site groundwater monitoring wells except for basal aquifer well MW08 (now named OWDFMW01) were abandoned and sealed (DON 2006). OWDFMW01 was retained to allow for continued monitoring of current site conditions, and was incorporated into the Navy's groundwater long-term monitoring (LTM) program at the Red Hill Bulk Fuel Storage Facility (RHSF) in 2009 (DON 2010).

During the RHSF groundwater LTM program, elevated concentrations of organics were reported by the laboratory as total petroleum hydrocarbons (TPH) diesel range organics (TPH-d) in OWDFMW01 in quarterly groundwater monitoring events in 2010, 2012, 2013, and 2015, and occasional detections below the DOH environmental action level (EAL) during other events (DON 2019b). Although the concentrations have since decreased, these detections were a change from conditions during the remedial investigation (RI), during which no analytes were detected in any of the basal groundwater samples (DON 2000). The cause of these TPH-d detections is not conclusively known, and determining the source, nature, and extent of the elevated concentrations requires additional investigation beyond the quarterly monitoring conducted under the RHSF groundwater LTM program. Because this petroleum release site is regulated exclusively under state law, and not federal law (DON 2001a), this proposed investigation is a Site Assessment consistent with the DOH *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (TGM) (DOH 2018).

11.2 STEP 2: IDENTIFY THE STUDY GOALS

The second step of the PQO process involves identifying the key questions that the study attempts to address, the alternative outcomes that may result based on the answers to these key questions, and the development of decision statements. The principal study questions identified for this project are as follows:

1. Do chemicals of potential concern (COPCs) exist in the basal groundwater aquifer at the OWDF at concentrations that may present unacceptable human health risks?
2. If measurable concentrations of "TPH-d" persist in in the basal groundwater aquifer at the OWDF:
    a. Which compounds comprise the reported concentrations of "TPH" and are those compounds petroleum-related?
    b. Can the on- or off-site source of the compounds or constituents be identified?
    c. Are there indications of ongoing natural attenuation in the groundwater at the OWDF?
    d. How do aquifer conditions affect contaminant fate and transport to and from the OWDF?

11.3 STEP 3: IDENTIFY THE INFORMATION INPUTS

The third step in the PQO process identifies the types and sources of information needed to answer the principal study questions, including:

- The decision statement
- The quality of information needed
- Whether the historical data are sufficient to make the decisions, or whether new data are required
- The quality control (QC) protocols

The following data and information will be collected to answer the principal study questions:

- Data representing chemical concentrations for groundwater samples collected at the site
- Locations of all groundwater samples collected at the site
- Analytical data reported by previous investigations
- Data representing parameters to evaluate the fate and transport pathways of the COPCs, including the following:
  - Geotechnical data from soil borings
  - Characteristics of free-phase petroleum product, if encountered
- Potentiometric and hydraulic data indicating the groundwater gradient, hydraulic conductivity, and the groundwater flow direction based in part on groundwater level measurements
- Soil and Groundwater screening criteria (Worksheet #15):
  - DOH EALs
- Results of previous human health and ecological risk assessments for the site

Table 11-1 summarizes the information needs, data requirements, and activities for the Site Assessment.

Table 11-1: Summary of Information Needs, Data Requirements, and Field Sampling Activities for the Site Assessment

Data Category	Information Need	Data Requirement	Field Sampling Activity
Nature and extent of groundwater impacts	Provide adequate data to evaluate the nature and extent of groundwater contamination.	Perched and basal groundwater COPC concentrations	Monitoring well installation; perched and basal groundwater sampling and monitoring
Water level study	Evaluate groundwater flow elevations, gradients, and direction, including under different Red Hill Shaft pumping conditions, if feasible. Determine whether hydraulic connections exist between groundwater beneath the OWDF and Red Hill Shaft, the RHSF USTs, or other potential sources.	Basal groundwater temperature, conductivity, and potentiometric elevations	Transducer water level study; land survey data; gyroscopic water level correction factors

Data Category	Information Need	Data Requirement	Field Sampling Activity
Fate and transport	Evaluate physical properties of aquifer water and site soil to evaluate contaminant fate and transport.	Groundwater NAP concentrations; soil geotechnical characteristics (e.g., Atterberg limits, PSD, TOC, pH)	Groundwater and soil sampling

COPC	chemical of potential concern
NAP	natural attenuation parameter(s)
OWDF	Oily Waste Disposal Facility
PSD	particle size distribution
RHSF	Red Hill Bulk Fuel Storage Facility
TOC	total organic carbon
UST	underground storage tank

11.4 STEP 4: DEFINE THE STUDY BOUNDARIES

The objective of Step 4 is to define the spatial and temporal study boundaries of the populations covered by the decision statement to ensure that the data are representative of the population. Practical constraints that could interfere with sampling are also identified. The spatial and temporal boundaries of the study are as follows:

- The horizontal boundary of the study encompasses the entire OWDF. Other area wells outside of the OWDF may also be analyzed.
- The vertical extent of the investigation is defined by the depths of the borings and monitoring wells to be sampled during the investigation, i.e., approximately 35–50 ft bgs for perched water borings and up to approximately 120–150 ft bgs for basal water borings.
- Temporally, the field effort will begin after the final OWDF *Site Assessment Work Plan* (WP) is submitted and approved, and may continue for up to approximately 2–3 years. The goal is to begin field work as soon as possible, tentatively in the fall of 2020. Based on available data, seasonal variations in site conditions do not appear to be significant.

11.5 STEP 5: DEVELOP THE ANALYTIC APPROACH AND DECISION RULES

Step 5 in the PQO process develops decision rules that will guide the analytical approach used to draw conclusions from the data. The following decision rules have been developed for the project:

1. If a COPC is not detected in groundwater samples collected from the OWDF or the reported concentrations do not exceed the project screening criteria, then recommend no further action for the COPC.
    a. If a COPC is detected in basal groundwater samples at the OWDF at a concentration above the project screening criteria, then evaluate if the COPC presents unacceptable risk to human health. If a COPC is detected in perched groundwater samples at the OWDF at a concentration above the project screening criteria, then evaluate the potential for transport to the basal groundwater.
    b. If no unacceptable risks exist, then recommend NFA for the site. Conversely, if unacceptable risks are identified, then evaluate potential response actions.
2. If TPH is detected in the groundwater samples collected from the OWDF, whether or not the concentration of TPH exceeds screening criteria, then attempt to identify or otherwise characterize the components of the TPH and evaluate relevant fate and transport processes with respect to potential source and exposure points.

11.6 STEP 6: SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

Step 6 identifies the criteria that will be used to determine whether the data are of sufficient quality to make the decisions outlined above. This subsection identifies the potential sources of study error and describes how those errors will be minimized throughout the investigation.

11.6.1 Sources of Error

Sources of error in an investigation can be divided into two main categories: sampling error and measurement error. A sampling error (field or laboratory) occurs as a result of a sampling design that does not allow for an equal probability of including any given part of the population of interest in the sample. A measurement error occurs as a result of performance variance from laboratory instrumentation, analytical methods, and operator error. The EPA identifies the combination of all these errors as the “total study error” (EPA 2006). One objective of the investigation is to reduce the total study error so that decision makers can be confident that the data collected accurately represent the chemical characteristics of the site.

11.6.2 Managing Decision Error

The investigation will use techniques to minimize decision error in sampling design, sampling methodologies, and laboratory measurement of COPCs. The following methods will be used during the field investigation to minimize possible decision errors:

- Evaluate all available historical data to identify COPCs, select appropriate sampling locations, and define site characteristics.
- Apply standardized well installation and field sampling methodologies (as discussed in Worksheets #14, #17, and #18). Well installation and sampling activities will be performed in accordance with the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015) and consistent with the Monitoring Well Installation WP and addenda (DON 2016b, 2017a, e) and the WP/Scope of Work (DON 2017b) for the Red Hill AOC Sections 6 and 7 investigation (EPA Region 9 and DOH 2015).
- Use applicable standard analytical methods (discussed in Worksheets #23, #24, and #25) for sample analysis by an analytical laboratory accredited by the Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP), to reduce measurement error.
- Use spikes, blanks, and duplicates (discussed in Worksheet #12) to identify and control potential laboratory and sampling errors.

Decision errors associated with judgmental sampling are based on sample design and measurement errors. Assuming that the best possible professional judgment was used to develop the judgmental sampling plan (i.e., position sampling locations), the most important decision errors will be associated with field and laboratory techniques involved in the collection and analysis of the data.

11.6.2.1 SAMPLING METHODOLOGIES AND PROCEDURES

Possible decision errors generated by sampling errors will be minimized during the field investigation by applying standardized field sampling methodologies (discussed in Worksheets #18, #20, #21, and #22). Sampling activities will be performed in accordance with the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015).

11.6.2.2 LABORATORY MEASUREMENT OF COPCS

Possible decision errors generated by laboratory measurement errors will be minimized using applicable analytical methods (discussed in Worksheets #23, #24, and #25) for sample analysis by an accredited analytical laboratory accredited by the DoD ELAP. The potential effect of laboratory measurement error will be discussed in the data usability assessment. In addition, because TPH results are method-dependent, employ multiple lines of evidence to evaluate TPH results, including review of chromatographic profiles, site conditions, COPCs, silica gel cleanup, and other forensic methods to contextualize reported laboratory results.

11.7 STEP 7: DEVELOP THE PLAN FOR OBTAINING DATA

In Step 7 in the PQO process, the acceptance criteria generated in Steps 1 through 6 are used to develop a resource-effective design for collecting and measuring environmental data. The sampling design is based on the project-specific DQO outputs, historical knowledge of the site, historical investigation results, estimates of variation, characteristics of the contaminants, and the contaminant transport. The following activities are proposed to meet the project objectives and complete the Site Assessment:

- *Re-evaluate the nature and extent of impacts to groundwater to ascertain whether any response actions are warranted.* The OWDF RI (DON 2000) concluded that contaminants at the site presented no significant risk to human health, and recommended NFA for soil at the site. Based on subsequent detections of TPH-d in basal groundwater samples collected from OWDFMW01, the conclusions of the RI require re-evaluation to ensure that human health continues to be protected. Groundwater monitoring wells will be installed in both the perched and basal aquifers beneath the site and will be sampled to determine whether there is groundwater contamination at the OWDF. Soil borings drilled for well installation will verify whether the multiple perched water layers encountered during the RI continue to be present at the site. Also, soil samples will be collected during monitoring well installation to assess the nature of subsurface soil properties and potential contamination, which, if present, may be a source of impacts to the groundwater. The results of these analyses will be screened against appropriate screening values to determine whether further action is recommended. Finally, the fate and transport of COPCs will be evaluated to determine whether the pathway to the current drinking water source is potentially complete.
- *Evaluate the nature of the reported TPH-d concentrations in OWDFMW01 and investigate potential onsite or offsite sources.* Given the sporadic detections of TPH-d in OWDFMW01 during the Red Hill LTM program and the fact that those laboratory results did not necessarily comport with petroleum fuel-related impacts, and considering the complexity of the regional groundwater system, the Site Assessment will investigate the nature, cause, and potential source of reported TPH concentrations. Consequently, results from new wells proposed at the OWDF as well as other area wells will be evaluated to investigate whether the TPH-d concentrations reported at OWDFMW01 during the LTM program is related to the 2014 fuel release at Tank 5 or other potential sources.
- *Integrate the findings of the OWDF and RHSF investigations and establish a comprehensive and current conceptual site model (CSM) for the OWDF.* Much of the RHSF investigation data and findings are relevant to the OWDF site, and, in turn, the OWDF investigation data and findings can augment the RHSF investigation. The OWDF investigation team will coordinate with the RHSF investigation team to share information learned regarding local and regional aspects of geology, hydrology, transducer study results, the confined or unconfined nature of basal groundwater, COPCs and their sources, releases, accumulation, and impacts.

A comprehensive and current OWDF CSM is essential for evaluating potential response actions (if necessary) and for understanding events like the TPH-d detections. Developing a comprehensive CSM will require evaluating results of groundwater sampling and analyses (from existing and new wells both at the site and regionally), geologic mapping and cross sections, hydraulic conductivity, a transducer study (to evaluate potentiometric surface elevations and groundwater flow direction), together with existing site data. The CSM will include site geology, hydrology, topography, land uses, and contaminant fate and transport characterization.

- *Document the OWDF Site Assessment findings and make site-specific recommendations.* Analytical data and findings from the OWDF Site Assessment will be presented in a Site Assessment report that will summarize the investigation's findings, evaluate the nature and extent of contamination and chemical fate and transport, and assess risks that may result from groundwater conditions at the OWDF. If no unacceptable risks are identified, then NFA will be recommended. If unacceptable risks are identified, then response alternatives, including development of a Remediation Action Plan or Environmental Health Management Plan, will be considered.

To gather these data, as described in Section 17.1, 56 groundwater samples plus quality assurance (QA)/QC samples are expected to be collected from 13 newly installed wells and one existing monitoring well. As described in Section 17.4, the groundwater data will be supplemented by collecting and analyzing up to 39 soil samples plus QA/QC samples from the seven proposed well clusters. The resultant sampling and analysis program for the OWDF Site Assessment is tabulated in Table 11-2.

Table 11-2: Sampling and Analysis Program, Red Hill OWDF Site Assessment

Analytical Method	Analytical Parameter	No. of Samples						
		Analytical Samples	Duplicate Samples [a]	MS/MSD Pairs [b]	Equipment Blanks [c]	Field Blanks [d]	Trip Blanks [e]	Total [f]
Groundwater COPCs [g]								
SW-846 8260	VOCs & TICs	56	8	4	4	4	56	136
SW-846 8015 or 8260	TPH-g (C6-C10)	56	8	4	4	4	56	136
SW-846 8015	TPH-d (C10-C24) & TPH-o (C24-C40)	56	8	4	4	4	—	80
SW-846 8270	SVOCs & TICs	56	8	4	4	4	—	80
SW-846 8270-SIM	PAHs	56	8	4	4	4	—	80
SW-846 8290	Dioxins/Furans	56	8	4	4	4	—	80
SW-846 3630C/8015	TPH-d/o using Silica Gel Cleanup	TBD [i]	—	—	—	—	—	TBD [i]
Groundwater Parameters								
EPA Method 300.0	Anions	56	—	—	—	—	—	56
SW-846-6010	Cations	56	—	—	—	—	—	56
SM 4500-SID	Silica (total & dissolved)	56	—	—	—	—	—	56
RSK 175	Methane	56	—	—	—	—	—	56
EPA Method 9060	Organic Carbon (total & dissolved)	56	—	—	—	—	—	56
SM 2320	Alkalinity (total, bicarbonate, and carbonate)	56	—	—	—	—	—	56
EPA Method 353.2	Nitrate-Nitrite Nitrogen	56	—	—	—	—	—	56
SM 3500 FeB	Ferrous Iron	56	—	—	—	—	—	56
Soil COPCs [h]								
SW-846 8260	VOCs & TICs	39	7	7	7	7	39	113
SW-846 8015 or 8260	TPH-g (C6-C10)	39	7	7	7	7	39	113
SW-846 8015	TPH-d (C10-C24) & TPH-o (C24-C40)	39	7	7	7	7	—	74
SW-846 8270	SVOCs & TICs	39	7	7	7	7	—	74
SW-846 8270-SIM	PAHs	39	7	7	7	7	—	74
SW-846 8290	Dioxins/Furans	39	7	7	7	7	—	74
Soil Chemistries								
Total Organic Carbon	Walkley-Black	13	—	—	—	—	—	13
pH	ASTM G51	13	—	—	—	—	—	13
Cation exchange capacity	SW-846 Method 9081	13	—	—	—	—	—	13

Analytical Method	Analytical Parameter	No. of Samples						
		Analytical Samples	Duplicate Samples [a]	MS/MSD Pairs [b]	Equipment Blanks [c]	Field Blanks [d]	Trip Blanks [e]	Total [f]
Geotechnical Parameters								
Atterberg Limits	ASTM D4318	13	—	—	—	—	—	13
Grain size distribution	ASTM D422	13	—	—	—	—	—	13
Soil Classification	ASTM D2488	13	—	—	—	—	—	13
Moisture content and density	ASTM D7263B	13	—	—	—	—	—	13
Effective porosity and permeability	ASTM D6836M and ASTM D5084	13	—	—	—	—	—	13
LNAPL or Sheen (if encountered)								
Hydrocarbon Characterization	Laboratory Specific (Fuel/Solvent fingerprinting and detailed chemical evaluation)	TBD [i]	TBD [i]	TBD [i]	—	—	—	TBD [i]

—	not applicable, no sample will be collected
ASTM	ASTM International
EPA	United States Environmental Protection Agency
LNAPL	light non aqueous phase liquid
MS	matrix spike
MSD	matrix spike duplicate
no.	number
PAH	polynuclear aromatic hydrocarbon
PSD	particle size distribution
SM	standard method
SVOC	semivolatile organic compound
SW-846	Hazardous Waste Test Methods
TBD	to be determined
TIC	tentatively identified compound
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics
VOC	volatile organic compound

[a] Duplicate samples based on 10% of analytical samples per sampling event.

[b] MS/MSD extra samples volume/mass will be collected based on 5% of analytical samples per sampling event. Analysis of MS/MSD will follow DOD QSM requirements.

[c] Equipment rinsate blanks based on 5% of analytical samples per sampling event.

[d] One field blank per water source.

[e] One trip blank per analytical method per shipping cooler, actual trip blank analyses may differ from planned.

[f] Total number of analyses includes QC samples.

[g] Four rounds of quarterly groundwater sampling will be conducted once all proposed new wells are installed. Pending site conditions encountered during drilling, 13 new wells are anticipated. See Worksheet #17.

[h] Up to three soil samples assumed per boring.

[i] Number of samples analyzed for TPH-d and TPH-o with silica gel cleanup is contingent on detections of TPH-d and TPH-o in non-silica-gel-cleaned samples.

Worksheet #12: Field Quality Control Samples

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group [a]	Frequency [b]	DQI	Measurement Performance Criteria
Field duplicate	All	10% of primary samples collected per matrix and analytical method for each sampling event	Precision	RPD ≤50% water [c] RPD ≤100% soil [c]
MS/MSD	All	5% of primary samples collected per matrix and per analytical method for each sampling event	Precision and Accuracy	Use QC acceptance criteria at least as stringent as specified by DoD Quality Systems Manual Version 5.3 (DoD and DOE 2019)
Equipment rinsate	All	5% of primary samples collected per matrix per analytical method	Representativeness; Adequacy of the decontamination process	≤1/2 of LOQ
Field blank	All	Once per source of decontamination water per sampling event	Representativeness; Adequacy of the decontamination water quality or potential for contamination due to field conditions	≤1/2 of LOQ
Trip blank	VOCs, TPH-g, Methane (soil, water)	At minimum, one per cooler containing samples for groundwater	Contamination during sample transport	≤1/2 of LOQ

%	percent
DoD	Department of Defense
DQI	data quality indicator
LOQ	limit of quantitation
MS	matrix spike
MSD	matrix spike duplicate
QC	quality control
RPD	relative percent difference
RSD	relative standard deviation
TPH-g	total petroleum hydrocarbons – gasoline range organics
VOC	volatile organic compound

[a] Refer to Worksheets #11 and #15 for a list of all analytical groups.
[b] Per Procedure III-B, *Field QC Samples* (DON 2015); refer to Worksheet #20 for a summary of QC samples by project location, matrix, and analytical group.
[c] Per Project Procedures Manual Section II, *Data Validation Procedures* (DON 2015).

Worksheet #13: Secondary Data Criteria and Limitations Table

Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator	How Data Will Be Used	Limitations on Data Use
Historical Data	1996 Phase I RI, Red Hill Oily Waste Disposal Facility (DON 1996a)	DON	Background information, analytical data, and results will be used to identify COPCs	None identified
	1996 Final Remediation Verification Report, Closure and Removal of Red Hill Stilling Basin (DON 1996b)	DON	Background information, analytical data, and results will be used to identify COPCs	None identified
	2000 Phase II RI, Red Hill Oily Waste Disposal Facility (DON 2000)	DON	Background information, analytical data, and results will be used to identify COPCs	None identified
	2003 8,000-Gallon AST Area Total Petroleum Hydrocarbon-Diesel Characterization Report (DON 2003)	DON	Background information, analytical data, and results will be used to identify COPCs	None identified
	2011-2020 Quarterly Groundwater Monitoring Reports, Red Hill Bulk Fuel Storage Facility	DON	Background information, analytical data, and results will be used to identify COPCs	None identified

COPC	chemical of potential concern
DON	Department of the Navy

Worksheet #14: Summary of Project Tasks

This worksheet provides a brief overview of project activities. The DON (2015) procedures cited in this worksheet are from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015), and are presented in Appendix A. Details of sampling design and rationale are presented in Worksheet #17.

14.1 SITE PREPARATION

14.1.1 Site Reconnaissance

A site reconnaissance will be performed in preparation for drilling and sampling activities. Field team personnel will identify potential boring locations, determine layout for equipment and staging materials, evaluate site conditions, and visually inspect the site for potential health and safety hazards.

14.1.2 Vegetation Clearance

Vegetation clearance will be performed by a qualified subcontractor to provide access for a drill rig and support truck. It is anticipated that a pathway up to approximately 150 ft long × 15 ft wide will be required to access location OWDFMW04 and an approximately 50 ft × 80 ft area will be also required to safely conduct drilling operations at this location. Light vegetation clearing may be required at other locations. Vegetation clearance and disposal activities will be conducted in accordance with Navy requirements for proper disposal of green waste to prevent the spread of the coconut rhinoceros beetle as described in the Department of the Navy JBPHH Green Waste Policy dated October 29, 2018 (Appendix A).

14.1.3 Access Pathway and Drilling Pad Construction

As described in Worksheet #17, one monitoring well cluster (OWDFMW04) is proposed to be installed in the relatively undeveloped area between the OWDF and the Red Hill Shaft. A pathway and drilling pad will be required to access and conduct drilling operations at this location. Grading will be performed as necessary to advance the pathway and to create a level drill pad in the cleared drilling location. The ground surface will be stabilized along the pathway for the movement of heavy equipment and the drilling pad will be established at the drilling location, by grading and filling to level the area, as much as practicable, to provide an even working surface for the drill rig and support truck. The full extent of the pathway and the drill pad will be finished with an 8-inch-thick layer of coarse gravel no larger than 6 inches. The pathway will be approximately 150 ft long × 15 ft wide, and the drilling pad will be approximately 50 ft × 80 ft.

14.1.4 Access Gate Construction

An access gate will be required at the entrance of the OWDFMW04 pathway to provide access to the monitoring well and to restrict other vehicles or use. The gate will be installed into an existing chain-link fence that borders Icarus Way. A small portion of the fence will be removed for the installation, and a double-swing chain-link access gate approximately 20 ft wide × 7 ft tall (to match existing fence height) will be then constructed. A three-strand barb wire extension will be installed above the gate for security. Existing grade will be restored to original condition after installation, and all removed materials will be disposed of at an appropriate offsite location.

14.2 SUBSURFACE UTILITY CLEARANCE AND GEOPHYSICAL SURVEY

A geophysical survey will be performed by a qualified subcontractor prior to intrusive activities. Radio frequency (RF), magnetic, electromagnetic (EM), and ground-penetrating radar (GPR) survey techniques will be conducted at proposed soil boring/monitoring well locations to determine the locations of underground utilities in accordance with Naval Facilities Engineering Systems Command, Pacific Environmental Restoration Program Procedure I-A-5, *Utility Clearance* (DON 2015). The purpose of the survey is to prevent damage to utilities during borehole drilling. Ultrasonic detection may be necessary to locate non-metallic (e.g., asbestos-cement, high-density polyethylene, or polyvinyl chloride [PVC]) utility lines that may not have tracer wire provisions. In addition, Hawaii One-Call will be called for utility clearance prior to any intrusive work.

14.3 DRILLING AND MONITORING WELL INSTALLATION

The proposed investigation includes drilling approximately 13 boreholes and installing monitoring wells in the basal drinking water aquifer and in the perched aquifer, where present. Seven monitoring well cluster pairs are proposed to be installed at the site in order to investigate the horizontal and vertical extent of groundwater impacts and evaluate the groundwater flow patterns in the site vicinity, including effects induced by the operation of the water supply pumps at the nearby Red Hill Shaft.

Each well cluster will consist of one “shallow” well completed in the first perched aquifer and one “deep” well completed in the basal aquifer, with the exception of OWDFMW04, which is not expected to encounter perched groundwater and will therefore likely only include a basal well. Based on data gathered during the OWDF RI, it is anticipated that, at most cluster locations, one well will be installed at approximately 25–50 ft bgs and one well will be installed to a maximum of approximately 150 ft bgs. The actual presence and depths of shallow and deeper water-bearing zones will be determined during drilling. Some cluster locations may not have a perched aquifer, and some may have more than one, in which case the number of perched wells in each cluster may be modified based on field conditions encountered.

The perched and basal aquifer monitoring wells will be drilled within 15 ft of each other (horizontal distance between boreholes) if feasible. The new monitoring wells will be labeled with a prefix of “OWDFMW,” followed by the cluster number (i.e., OWDFMW02, OWDFMW03, …, OWDFMW08). Within each cluster, the individual well designations will include a suffix “A” (e.g., OWDFMW02A) to indicate a basal monitoring well and a suffix “B” to indicate a perched monitoring well (e.g., OWDFMW02B); should a second perched well be installed in any location, it will bear the suffix “C.”

The anticipated monitoring well cluster locations and identifiers are presented in WP Supplement Figure 16.

14.3.1 Drilling

Prior to any drilling, a hand auger or other hand tool will be used to manually advance the borehole to 5 ft bgs to ensure the location is cleared of utilities. Each borehole will be drilled using a drilling rig equipped with hollow-stem augering, rock coring, and air rotary capabilities in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Boreholes will initially be advanced to refusal using a minimum 4¼-inch-inner-diameter hollow-stem auger that can be used as a temporary surface casing during rock coring activities. Characterization samples of unconsolidated material will be collected at 5-ft intervals beginning at 10 ft bgs with 1.5-ft-long, 2.5-inch-diameter split spoons.

Potentially impacted perched water is anticipated to be encountered in the vadose zone at all locations except OWDFMW04. To minimize the potential for perched water or contamination to migrate downward and impact the basal aquifer, which is a drinking water source, a surface or conductor casing composed of 10-inch-diameter Schedule 40 low-carbon steel will be installed in each basal well borehole. The purpose of the conductor casing is to isolate freshwater zones so that they are not contaminated and to prevent cross contamination between the perched groundwater or contaminated unconsolidated material and the basal aquifer. To facilitate identification of perched groundwater or contaminated unconsolidated material, water levels, if present in the borehole, will be measured at the beginning and end of each day, frequently during drilling efforts, and before drilling has started and after drilling has been completed for each day. Additionally, the presence of contamination may be indicated by staining on drill cuttings and recovered rock cores and by elevated photoionization detector (PID) readings. This information will be recorded in the project field logbook.

The diameter of the borehole will be at least 4 inches greater than the outer diameter (OD) of the 10-inch-diameter Schedule 40 low-carbon steel conductor casing. The conductor casing will be centered within the borehole using stainless steel centralizers spaced at approximately 40-ft intervals. The centralizers will be aligned so that they do not interfere with the insertion and removal of the tremie pipe, if necessary. The annular space to be grouted will be a minimum of 2 inches beyond the casing. The conductor casing will be pressure-grouted in place as soon as possible after installation using a packer assembly and tremie pipe installed inside of the conductor casing that will allow the grout to be pumped through the packer assembly until it rises to the ground surface around the casing, or with tremie placed in the annular space around the casing. The annulus will be sounded to check for settling of the grout within 24 hours of placement. Placing the grout in the annular space will be done in stages with time allowed for the grout to set between stages in order to prevent distortion or collapse of the casing by heat or pressure. Following the pressure grouting procedure, the grout will be left undisturbed for a minimum of 24 hours for curing.

In bedrock, subsurface material will be continuously sampled using rotary wireline coring to describe the subsurface material and record the lithologic characteristics during the drilling of the wells in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Continuous rock cores will be collected as the monitoring well boreholes are advanced through the basaltic bedrock. All drilling in rock will be accomplished by diamond core drilling methods in general accordance with ASTM D2113 (ASTM 2014).

The drill rig will be equipped with 5-ft-long, 3.78-inch-OD core barrels (yielding a 2.5-inch-diameter rock core [HQ bit size]), and the cores will be recovered with a wireline and quad-latch retrieval system. A 4.83-inch OD core barrel (yielding a 3.35-inch-diameter rock core [PQ bit size]) may also be used, depending on site conditions.

The cores will be inspected and logged to characterize the lithology and evaluate potential pathways for migration of light nonaqueous-phase liquid (LNAPL) and associated constituents, if present. In general, each log will note: rock-quality designation; color; texture; strength; degree and orientation of fracturing; shape, size, and volume of voids; weathering; and secondary staining or mineralization. High-resolution photographs of the cores will be taken and detailed photo logs will be prepared. The Geological Society of America rock color chart with Munsell color chips will be used for color characterization. Lithologic descriptions, PID screening results, and other observations will be recorded on the geologic logs.

After rock coring is complete, each borehole will be reamed to total depth with a conventional, open-hole air rotary drilling rig to increase the borehole diameter to a minimum of 8.5 inches, as required for monitoring well installation. Clean, potable water (and environmentally safe drilling foam, only if pre-approved by the Navy) will be injected during drilling to mitigate dust and remove cuttings from the boreholes. Inline granular activated carbon filters will be used during drilling when water is pumped downhole to facilitate drilling. Prior to use, potable water for drilling will be sampled and analyzed for chemicals of potential concern (COPCs) as described in Section 14.4.1. Cuttings removed from the boreholes will be collected in 55-gallon drums equipped with air stacks to reduce dust or, alternatively, into roll-off bins.

14.3.2 Well Installation

After the boreholes have been reamed with the air rotary drilling equipment groundwater monitoring wells will be installed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Four-inch-diameter, Schedule 80 PVC-cased monitoring wells will be constructed within the boreholes at these locations. The wells will be screened within the basal aquifer with at least 20 ft of 0.02-inch slotted screen, and will be completed within the perched zones with at least 10 ft of well screen spanning the groundwater surface.

To ensure the 4-inch-diameter casing is centered in the 8.5-inch-diameter borehole, centralizers will be installed at the top and bottom of screened sections and also placed at 40-ft intervals on blank well casing. The centralizers will be aligned from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe. Centralizers will be constructed of stainless steel. To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, the 4-inch-diameter well casing and screen will be suspended with a threaded hoisting plug and not allowed to rest on the bottom of the borehole. Coarse #3 Monterey silica sand will be emplaced via tremie pipe into the borehole annulus to approximately 5 ft above the well screen, followed by a 5 ft-thick bentonite pellet seal, then wet bentonite grout slurry (Wyo-Ben Enviroplug Grout or equivalent) to the base of the conductor casing. If large voids are encountered, bentonite chips may be required to seal the voids. The bentonite slurry (or chips, where required) will be slowly placed via tremie pipe to ensure proper filling of the annulus and to avoid bridging. Dry bentonite chips, where used, will be tremied and hydrated with clean, potable water using at least 5 gallons of water per 50-pound bag of chips. For basal aquifer wells, the annular space between the 4-inch-diameter well casing and the 10-inch conductor casing will be finished by pressure grouting with cement bentonite grout to near surface or with tremie placed in the annular space around the casing. Well construction diagrams will be provided on the geologic logs.

After the well is completed, a quantitative true vertical depth analysis using a gyroscopic alignment instrument will be performed in the basal aquifer wells so that appropriate corrections can be made to wireline-measured depth to water.

14.3.3 Well Development

The monitoring wells will be developed to remove sediment and stagnant water and to enhance the recharge of groundwater into the wells. Monitoring well development will be performed in accordance with Procedure I C-2, *Monitoring Well Development* (DON 2015) at least 24 hours after the completion of well installation to allow the annular seal to fully set. Well development will consist of a combination of surging and bailing techniques and pumping groundwater with a submersible pump until fine sediment particles have been removed and the water clarifies. This normally occurs after removing between five and ten well volumes, and ensures that formation water enters the well and that the water affected by drilling is removed. The parameters of dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, specific conductance, turbidity, and salinity will be monitored during the development cycle. Because DO and ORP are affected by the agitation of surging and pumping, the values obtained for these parameters during development may vary and are not representative of the aquifer water. If the development water is not relatively clear and sediment free after ten well volumes, it will be assumed that further development will not be beneficial, and development will be considered complete. The well development activities will be documented in the field logbook and on computer-generated well development forms.

14.3.4 Dedicated Groundwater Pump System Installation

A dedicated pneumatic bladder pump groundwater sampling system will be installed in each monitoring well after well development is complete. The sampling system will consist of a Type 316 stainless-steel bladder pump with a screen intake located 3 ft below the top of the pump, small-diameter Teflon-coated Type 316 stainless steel safety cable, polyethylene air and discharge tubing, and a well cap assembly with fittings. The bladder pumps will be installed with the screen intake approximately 10 ft below the water table in the deep basal aquifer wells and approximately 4 ft below the water table in the shallow perched aquifer wells. Cable ties will be applied approximately every 10 ft to secure the tubing to the safety cable. The sampling ports of the bladder pump system terminate in a PVC plate and are part of the well cap assembly, which consists of the PVC plate and a sleeve that slips over the 4-inch well casing at the well head.

14.3.5 Borehole Abandonment

Boreholes may be abandoned if drilling refusal occurs prior to reaching the target depth for well construction. Abandonment will be performed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015), which involves sealing the borehole with cement-bentonite grout. The grout will be placed with a tremie pipe in one operation from the bottom of the boring to within a minimum of 2 ft bgs. Additional grout may need to be placed if settlement occurs.

14.3.6 Monitoring Well Surface Completion

The monitoring wells will be completed in accordance with Procedures I-C-1, *Monitoring Well Installation and Abandonment* and I-C-2, *Monitoring Well Development* (DON 2015). Monitoring wells will be completed above ground with an 8-inch-diameter steel protective casing fitted with a locking, tamper-proof lid that covers the protective casing and well head. The lock will be recessed and covered for added protection, and permanent labels will be applied both inside and outside of the casing via painting, marking, or engraving on the protective casing or surface completion. The steel casings will be set in concrete at the well head for strength, security, and to provide a surface seal. A 3.5-ft × 3.5-ft square concrete pad, 2 ft thick, will be installed around each protective steel casing. The minimum stickup height of the steel casing will be 3 ft. Approximately 1 ft of the concrete pad will extend above the ground surface. The protective steel casings will extend above the well casings so that there is approximately 6 inches of clearance between the well head and locking lid. Coarse sand will be poured into the space between the well and protective casing to a level of approximately 6 inches below the well head. Four steel bollards will be placed slightly beyond each corner of the concrete pads. The bollards will extend approximately 2 ft bgs and approximately 3 ft above ground surface, and each will be individually set in concrete. The bollards and protective steel casing will be painted bright yellow for high visibility.

14.4 SAMPLE COLLECTION

The Site Assessment includes the collection and laboratory analysis of soil and groundwater samples to determine if contamination is present. Sample collection and laboratory analytical methods for samples, as well as the rationale for selecting sample locations and criteria to be used for selection of specific depth intervals for analysis, are presented in Worksheet #17. Refer to Worksheets #18 and #20 for further detailed location-specific methods and the complete sampling schedule.

14.4.1 Potable Water Sampling

Prior to using potable water during drilling and well installation activities, a potable water sample will be collected for laboratory analysis of COPCs to characterize the potable water. The potable water analytical results will be evaluated to determine if the potable water is a possible source of contamination to the drinking water aquifer during drilling activities. Collection of the potable water sample will be conducted in accordance with Procedure I-B-5 *Surface Water Sampling,* and samples will be handled in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015). Potable water will be collected from the water source directly into laboratory-provided sample containers. Vials for volatile organic compound (VOC) samples will be filled completely, with no headspace. Samples will be labeled with the sampling location, date and time of collection, and unique sample identifier as discussed in Section 27.2, and recorded in the field logbook. Sample containers will be placed in resealable plastic zip bags, kept in coolers containing wet ice, and preserved in accordance with analytical method requirements. Samples will be shipped to the laboratory via overnight airfreight.

14.4.2 Subsurface Soil Samples

Discrete subsurface soil samples will be collected for laboratory analysis of COPCs to provide additional data on the level of contamination present in the area (if any) and to assess potential impacts to groundwater from leaching. Subsurface soil will be collected from split-spoon samplers at the following depths:

- The capillary fringe of each perched and basal aquifer
- The top of each aquitard underlying each perched aquifer
- Areas where field observations suggest the potential for contamination

The collection of subsurface soil samples will be conducted in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). The samples will be inspected for evidence of contamination (visual, olfactory, or elevated PID readings) to evaluate the potential migration of LNAPL and associated constituents. Using the discrete sampling approach, approximately 100 grams of soil for non-VOC analyses will be collected using disposable scoops or spoons and placed in appropriate containers for each subsurface soil sample. Material collected for VOC analysis will be collected using 5-gram plugs using EnCore, Terra Core, or equivalent samplers. To minimize VOC loss during the sampling effort, the VOC sample plugs will be collected as quickly as possible and placed in laboratory-supplied water- and methanol-preserved containers. All sample containers will be labeled with the sampling location, date and time of collection, and unique sample identifier as discussed in Section 27.2, and recorded in the field logbook. In addition to the primary samples, duplicates and matrix spike/matrix spike duplicate (MS/MSD) samples will be collected along with other blank samples, as indicated in Worksheet #12.

The COPC analytical suite for soil is composed of the following:

- TPH-g, TPH-d, and TPH-o
- VOCs with tentatively identified compounds (TICs)
- SVOCs with TICs
- PAHs
- Dioxins/furans

14.4.3 Geotechnical Samples

Geotechnical samples will be collected using split-spoon samplers with stainless-steel liners. At least one geotechnical sample will be collected per well as bulk and undisturbed soil samples at the capillary fringe and where evidence of contamination is observed, and will be analyzed for the following:

- Atterberg limits
- Effective porosity and permeability
- Moisture content and density
- Grain size distribution
- Cation exchange capacity
- pH
- Soil classification
- Total organic carbon (TOC)

14.4.4 Groundwater Samples and Monitoring Program

Four rounds of quarterly groundwater sampling will be conducted at the existing well (OWDFMW01) and the new monitoring well clusters (OWDFMW02–OWDFMW08). Groundwater sampling will involve measuring the depth to water, detecting any floating free product in wells, purging stagnant water, and sampling the wells.

Depth to water will be measured in each well from a marked location that has been surveyed by a professional registered surveyor. An oil/water interface probe will be used to determine the depth to water to an accuracy of 0.01 ft. In addition to the water level determination, the interface probe will also be used to detect any free product that might be present in the well. If free product is present, the thickness will be measured to within 0.01 ft by measuring the depth to the oil/air interface and the depth to the oil/water interface. Groundwater samples will not be collected from wells in which greater than 0.01 ft of free product is measured.

After completing the well gauging procedures, the well will be purged with a bladder pump using low-flow purging techniques. An in-line flow-through cell will be used to measure groundwater parameters (e.g., temperature, conductivity, turbidity, oxidation-reduction potential, dissolved oxygen) during the purging process prior to discharge from the pump tubing. The flow rate will be adjusted during purging and sampling to minimize drawdown in the well. Ideally, drawdown will be less than 0.2 ft to prevent mixing within the borehole and allow the collection of a groundwater sample that is representative of groundwater conditions in the aquifer adjacent to the pump inlet. Purging will continue until the formation water has stabilized to within 10 percent on three successive readings.

The bladder pump used to purge the well will also be used to collect groundwater samples. At no time will flow rates exceed those used to purge the well. Aliquots of groundwater for laboratory analysis will be collected from each monitoring well in order of chemical stability (least stable to most stable). Sample containers will be pre-preserved by the laboratory, as necessary, and all sampling information will be recorded on a field sampling form. In addition to the primary samples, duplicates and MS/MSD samples will be collected along with other blank samples as indicated in Worksheet #12.

The COPC analytical suite for groundwater consists of the following:

- TPH-g, TPH-d, and TPH-o
- VOCs with TICs
- SVOCs with TICs
- PAHs
- Dioxins and furans

The groundwater analytical suite will also include the following natural attenuation parameters (NAPs): dissolved oxygen, ferrous iron, methane, sulfate, nitrate, chloride, and carbon dioxide. In addition, both laboratory and field measurements of pH will be made to evaluate elevated levels that have been reported in groundwater samples collected from OWDFMW01 during previous investigations.

14.4.5 Sheen Sampling

No measurable LNAPL or sheen has been detected in the monitoring well OWDFMW01 or any of the other regional wells that are monitored in the RHSF LTM program in previous monitoring events. If LNAPL layers are present or if sheens are observed, sheen samplers capable of sorbing LNAPL will be deployed in the monitoring wells. Vendor-supplied sheen samplers connected to a decontaminated water level tape (or similar) will be lowered to the groundwater surface in monitoring wells that have evidence of LNAPL or sheens. Once in the water, the sheen sampler's paper wrap will disintegrate to open the sampler. The sampler will be "bobbed" on the groundwater surface to open the sampler "skirt" and expose the sorbent material to the water for a minimum of 5 minutes. Using the water level tape, the sampler will be retrieved and placed in a laboratory-supplied glass jar for analysis. The sampling duration and water level will be recorded.

14.4.6 LNAPL Samples and Free-Phase Product Characterization

If LNAPL is encountered during well installation or groundwater monitoring events, LNAPL samples will be collected to characterize the LNAPL and the concentration of COPCs in the LNAPL. Samples will be collected using a bailer and analyzed for fuel type and other COPCs. Free-phase petroleum product samples will be submitted for fuel fingerprint analysis and aging to determine the extent of these differences and characterize the free product encountered in the monitoring wells. Collection of LNAPL will be done in accordance with Procedure I-C-3, *Monitoring Well Sampling*, Section 5.3.5 (DON 2015).

14.4.7 Quality Control Samples

Field QC samples will be collected to evaluate field variability and sampling error in accordance with Procedure III-B, *Field QC Samples* (DON 2015). Refer to Worksheets #12 and #20 for a summary of the field QC samples that will be collected on this project. The laboratory will also prepare and analyze QC samples. These may include blanks, surrogates, laboratory duplicates, MS/MSD, laboratory control samples, and any other applicable QC criteria defined in Procedure III-A, *Laboratory QC Samples* (DON 2015). Worksheet #28 presents a list of the laboratory QC samples for this project. No field and equipment blanks will be collected for potential sheen samplers and free product fuel samples.

14.5 SAMPLE MANAGEMENT

To ensure sample quality and representativeness, all samples will be appropriately managed from the time of collection through the time of relinquishment to the certified analytical laboratory. Each sample will be assigned a unique chain-of-custody (COC) sample identification (ID) number and a descriptive sample ID number to identify the sampling location, type, sequence, matrix, and depth of each sample. Sample information including the COC sample ID number, descriptive sample ID number, date and time of collection, sample analyses, number and type of containers, sample type, sample location, and types of preservative will be recorded in the QA/QC logbook and in accordance with Procedure III-D, *Logbooks* (DON 2015).

A label will be affixed to each sample container to identify the sample, the date and time of collection, site name, the laboratory analyses, preservative, sample type, and the field personnel who collected the sample. Custody seals will also be affixed to each sample container to ensure that the samples have not been tampered with prior to laboratory analysis. Samples will be placed on ice immediately after collection (except for geotechnical samples). COC forms and samples will be packed in coolers and shipped via FedEx or equivalent to the DoD ELAP-accredited laboratory.

Samples will be identified in accordance with Procedure I-A-8, *Sample Naming* (DON 2015) and as described in Worksheet #27. Samples will be managed and shipped in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and Procedure III-F, *Sampling Handling, Storage, and Shipping* (DON 2015).

14.6 FORENSIC ANALYSES, EVALUATION, AND TPH FRACTIONS

Forensic analyses will be performed to evaluate the chemical composition and carbon fraction distribution of light nonaqueous-phase liquid (LNAPL), sheen, or groundwater impacted by TPH.

Forensic analyses and evaluation of groundwater, sheen, or NAPL (if present) will include:

- Identifying compounds in the C3–C44 range present in jet fuel using ASTM D3328 or ASTM D5739.
- Identifying the specific highest concentration analytes in the volatile and semivolatile range of organic compounds using United States Environmental Protection Agency (EPA) Method 8260, EPA Method 8270 and EPA Method 8270SIM, respectively, and reporting at least the top ten TICs.
- Identifying the specific highest concentration analytes (including TICs) in the semivolatile range of organic compounds in the silica-gel-cleaned extract using EPA Method 3630 and analyzed by EPA Method 8270 to evaluate compounds that may be biodegradation by-products.
- Evaluating TPH polar and non-polar fractionation of TPH-diesel range organics (TPH-d) and TPH-residual range organics (TPH-o) using silica gel cleanup (SGC) by EPA Method 3630 and analyzed by EPA Method 8015.
- Identifying the parent and alkylated polynuclear aromatic hydrocarbons (PAHs) using EPA Method 8270 Selective Ion Monitoring (SIM) Mod.

Forensic analyses and evaluation of groundwater TPH will also include:

- Quantifying aliphatic and aromatic compounds within specific carbon ranges in the respective volatile and extractable portions using Massachusetts (MA) volatile petroleum hydrocarbon (VPH) and extractable petroleum hydrocarbon (EPH) methods for risk assessment.
- Quantifying aliphatic and aromatic compounds within the volatile and extractable portions using Texas Commission on Environmental Quality (TCEQ) methods 1005 and TCEQ 1006.

14.7 LAND SURVEY

A licensed land surveyor will locate, mark, and determine the coordinates of the new monitoring wells and pertinent site features in accordance with Procedure I-I, *Land Surveying* (DON 2015). It is anticipated that the land surveying activities will be conducted after drilling and sampling have been completed to determine the horizontal and vertical (elevation) coordinates of each location. The land survey of the wells will meet Second Order, Class I Survey requirements to measure precise elevation and location coordinates for the top of casing and ground surface of the 13 anticipated new groundwater monitoring wells. All land survey activities will meet requirements specified in Precise Digital Level to National Geodetic Survey Standards for land surveying.

14.8 GROUNDWATER TRANSDUCER STUDY

A transducer study will be conducted to evaluate groundwater mobility, groundwater parameters over time, and groundwater elevations compared to Navy Supply Well 2254-01 during supply well pumping and, if possible, non-pumping conditions. All seven proposed new basal wells and existing well OWDFMW01 will be included in the study. Additional nearby wells located outside of the OWDF may also be added to the study. Data will be collected over the course of one year, concurrent with the quarterly groundwater monitoring events, using automated in-well probes, and with readings occurring every 10 minutes. Temperature, conductivity, and water levels will be recorded automatically by the in-well probes.

14.9 EQUIPMENT DECONTAMINATION

All equipment decontamination will be performed in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015). Decontamination of non-disposable soil and groundwater sampling equipment (e.g., drilling rods, sample liners, water level meter) is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Decontamination of non-disposable equipment will be conducted before each use and upon completion of sampling activities.

The decontamination of drilling and heavy equipment (i.e., rods, augers, and tremie pipes) will be completed by high-pressure steam cleaning, followed by rinsing with potable water. The decontamination procedure for reusable sampling equipment (e.g., split spoons, bladder pump) will consist of the following:

1. Wash with a non-phosphate detergent (Alconox, Liquinox, or other suitable detergent) and potable water solution.
2. Rinse in a bath with potable water.
3. Spray with laboratory-grade isopropyl alcohol.
4. Rinse in a bath with deionized or distilled water.
5. Spray with deionized or distilled water.

14.10 INVESTIGATION-DERIVED WASTE MANAGEMENT AND DISPOSAL

It is anticipated that the following types of IDW will be generated during the field investigation:

- Soil cuttings from soil boring and well installation activities
- Purge water from groundwater sampling activities
- Fluids generated during decontamination of non-consumable sampling equipment (e.g., oil/water interface probe, drill rig, and augers)
- Miscellaneous IDW, anticipated to be comprised primarily of spent disposable personal protective equipment

IDW will be marshaled and stored on site, and will be handled, stored, and labeled in accordance with Procedure I-A-6, *IDW Management* (DON 2015). Unless otherwise indicated, IDW will be stored temporarily in 55-gallon drums, to be located on wood (solid IDW) or spill containment (liquid IDW) pallets in a Navy-approved equipment staging area.

IDW will be disposed of within 90 calendar days after receipt of the IDW analytical results. The IDW inventory and analytical data obtained during the investigation will be evaluated to select appropriate disposal methods. The evaluation will include review of Resource Conservation and Recovery Act and Toxic Substances Control Act regulations, and discussion with facilities authorized to receive Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) wastes.

14.11 ENVIRONMENTAL FORENSICS INVESTIGATION

Environmental forensics techniques will be used to assist in the identification of the origins or source of any contamination found at the site and to evaluate pathways by which contaminants may have reached that location. The environmental forensics site investigation will be conducted as needed, based on the potential presence of LNAPL, sheen, or detectable TPH, and will be reliant on the field investigation and subsequent laboratory-based analysis for confirmation of contaminants present. The forensics investigation will be conducted by using existing site data, historical information, and new data that will be collected from the site during this investigation and will include the following:

- Evaluating results for OWDFMW01 samples from the ongoing LTM program to better understand historical results.
- Evaluating previous data from OWDFMW01 using multiple lines of evidence (LOEs) to determine whether detections of site COPCs correlated to the laboratories used for sample analysis or actual impacts to groundwater.
- Reviewing, compiling, and documenting TICs and other non-COPCs results as well as available chromatographic profiles from sporadic TPH detections in LTM samples from OWDFMW01.
- Reviewing all new soil and groundwater data including numerical results and chromatograms for samples analyzed during this Site Assessment.
- Investigating detections of COPCs and any TICs reported by the laboratory for validity and relevance with respect to site operational history.

- Investigating TPH detections to determine potential source (e.g., historical site operations, biogenic metabolites of hydrocarbons, potential offsite sources, naturally occurring sources, or background chemistry).
- Evaluating analytical data along with geochemical data and other site data using multiple LOEs to support conclusions.

Additionally, if sheen, LNAPL, or soil with sufficient TPH concentrations (detections approximately greater than 1,000 milligrams per kilogram [mg/kg]) are encountered during sampling, a more detailed forensics investigation will be conducted in a phased approach starting with an evaluation of the chromatographic profiles (e.g., fuels, solvents, chemicals, etc.) followed by additional testing such as detailed hydrocarbon analysis.

14.12 DATA EVALUATION (TIER 1)

For the Site Assessment, analytical results will be evaluated in comparison with the project screening levels (PSLs), which are defined as the State of Hawaii Department of Health (DOH) Tier 1 environmental action levels (EALs) (DOH 2017):

- Table A-2 soil action levels (potentially impacted groundwater is a current or potential drinking water resource and surface water body is located within 150 meters of release site)
- Table D-1a groundwater action levels (groundwater is a current or potential drinking water resource and surface water body is located within 150 meters of release site)

14.13 DATA

Data generated during this investigation will include the following:

- VOCs (with TICs), SVOCs (with TICs), TPH-g, TPH-d, TPH-o, PAHs, dioxins and furans, and NAP concentrations reported for soil and groundwater samples.
- Soil geotechnical data including: Atterberg limits, effective porosity and permeability, moisture content and density, grain size distribution, cation exchange capacity, pH, soil classification, and TOC.
- Physical characteristics of soils and rock core recorded on bore logs including: Unified Soil/Rock Classification System; color (Munsell Soil Color Chart); soil grain size classification by percent; moisture content; structure, particle shape, angularity, and maximum size; plasticity of fines; odor and staining; and rock fracture.
- Monitoring well construction logs.
- Borehole geophysical logging data from basal aquifer wells prior to casing operations.
- Gyroscopic survey data (true vertical depth) for all newly installed monitoring wells.
- Data recorded on monitoring well development and groundwater sampling logs, which will include groundwater quality data (temperature, conductivity, turbidity, oxidation reduction potential, and dissolved oxygen), and static water level.
- Survey data on top of casing.
- Free product thickness (if encountered) and groundwater level monitoring data.

- Groundwater transducer study data (temperature, conductivity, and water level collected for 30 consecutive days, with readings occurring every 10 minutes).
- Product or sheen characterization results (if encountered), including fuel fingerprint analysis.
- Results of the environmental forensics investigation.

14.13.1 Data Management Tasks

All analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in an AECOM Technical Services, Inc. (AECOM) electronic database. All hard copies of analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in the AECOM Honolulu office, as detailed in Worksheet #29.

14.13.2 Documentation and Records

All field observations and measurements will be recorded in a field notebook and project-specific field data sheets. All samples will have global positioning system (GPS) locations. COC forms, air bills, and sample logs will be prepared and retained for each sample. See Worksheet #21 for a list of documentation standard operating procedures (SOPs). All data will be included in the investigation report.

14.13.3 Assessment/Audit Tasks

The project chemist, QA program manager, and field manager will be responsible for assessment and audit tasks (Worksheet #7). The contract task order (CTO) manager will be responsible for coordinating the field audit.

14.13.4 Data Reporting

The analytical laboratory will verify, reduce, and report data as specified in their DoD ELAP-evaluated laboratory QA plan. Reported data will be provided as hard copy and electronic data deliverables (EDDs). The laboratory deliverables will be consistent with Appendix A of the *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, Version 5.3 (DoD and DOE 2019).

Analytical data will be submitted by the laboratory to the data validation firm as hard copy and an electronic file. The electronic file will be created by transferring the analytical data package to a Microsoft Access database. The database will be parsed through internal verification and validation checks. Internal verification and validation checks are performed to identify data entries that exceed the specified QC criteria. If QC criteria are not met or if errors are identified due to an incorrect or incomplete laboratory submittal, the data package will be returned to the laboratory for correction and resubmittal.

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

14.13.5 Data Review Tasks

All analytical laboratory data results will be validated by a third-party data validation firm. Third-party data validation will consist of standard validation (90 percent) and full validation (10 percent). The first 10 percent of project field data (COPCs) generated by the laboratory will be validated at full validation to establish a baseline, ensuring the laboratory has complied with the requirements outlined in both the analytical methods and the DoD QSM Version 5.3 (DoD and DOE 2019). In addition, data quality checks (i.e., evaluating the precision and accuracy) will be performed once the analytical data are received from the laboratory. AECOM will verify the data against the specified limits of quantitation (LOQs) and limits of detection (LODs) in Worksheet #15. All documents produced for the project will be kept in a secured facility for the life of the project. Upon closure of the project, laboratory documents will be archived with the project report in the administration record file at Naval Facilities Engineering Systems Command, Pacific.

In addition, all project analytical data will be validated by a third-party data validation firm in accordance with the following Data Validation Procedures (DON 2015):

- Procedure II-A, *Data Validation*
- Procedure II-B, *Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260*
- Procedure II-C, *Level C and Level D Data Validation for GC/MS Semivolatile Organics by SW-846 8270 (Full Scan and SIM)*
- Procedure II-D, *Level C and Level D Data Validation for HRGC/HRMS Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by SW-846 8290*
- Procedure II-H, *Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015*
- Procedure II-Q, *Level C and Level D Data Validation for Metals by SW-846 6000/7000*
- Procedure II-R, *Level C and Level D Data Validation for Wet Chemistry Analyses*
- Procedure II-S*, Data Quality Assessment Report*

Data received from the validation firm will be uploaded into AECOM's Microsoft SQL Server 2005 which is managed via EQuIS (Environmental Data Management Software).

Worksheet #15: Reference Limits and Evaluation Tables

This worksheet presents a detailed list of the soil and groundwater chemicals of potential concern (COPCs) that will be analyzed and corresponding project screening levels (PSLs), including:

- Volatile Organic Compounds (VOCs) – EPA SW-846 Test Method 8260
- Semivolatile Organic Compounds (SVOCs) – EPA SW-846 Test Method 8270
- Polynuclear Aromatic Hydrocarbons (PAHs) – EPA SW-846 Test Method 8270SIM
- Total Petroleum Hydrocarbons Gasoline Range (C_6-$C_{10\text{-}2}$) Organics (TPH-g) – EPA SW-846 Test Method 8260
- Total Petroleum Hydrocarbons Diesel ($C_{10\text{-}2}$-C_{25}) and Lube Range (C_{25}-C_{40}) Organics (TPH-d and TPH-o) – EPA SW-846 Test Method 8015
- Polychlorinated Dibenzo-Dioxins (PCDDs) and -Furans (PCDFs) – EPA SW-846 Test Method 8290

Soil PSLs were identified as the DOH Tier 1 EALs (Table A-2 soil action levels [potentially impacted groundwater IS a current or potential drinking water resource; surface water body IS located within 150 meters of release site]) (DOH 2017). Groundwater PSLs were identified as the DOH Tier 1 EALs (Table D-1a groundwater action levels [surface water ≤ 150 meters and potential drinking water source]).

The PSL for each chemical is provided below in Sections 15.1 and 15.2 for groundwater and soil, respectively. The tables will later summarize the laboratory-specific values for the limit of quantification, limit of detection, and detection limits (currently are all values are to be determined). Following selection of the analytical laboratory(s) and based on limitations of the analytical instrumentation, the standard limit of detection may exceed the screening criteria. In such cases, analytes reported as non-detected in samples will be treated as not exceeding the PSLs. Based on the investigation findings, an evaluation will be conducted to assess potential risk related to COPCs that exceed the PSLs. The usability and limitations of non-detect data of analytes with laboratory reporting limits above the PSLs will also be evaluated in a data quality assessment report.

Section 15.1 additionally lists the planned analyses selected to evaluate groundwater chemistry, natural attenuation parameters, and the microbial environment. Section 15.2 also lists the analytical methods selected to evaluate soil chemistry and the planned geotechnical analyses.

15.1 GROUNDWATER REFERENCE LIMITS

Matrix: **Groundwater**

Analytical Group: **VOCs and TICs (EPA SW-846 Method 8260)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
Acetone	67-64-1	1500	1500	462	140	10	2	0.95
Benzene	71-43-2	5	5	0.15	0.05	1	0.3	0.15
Bromodichloromethane	75-27-4	0.14	0.14	0.04	0.01	1	0.3	0.14
Bromoform	75-25-2	80	80	1.1	0.3	1	0.3	0.14
Bromomethane	74-83-9	7.6	7.6	0.25	0.08	2	0.5	0.24
Carbon Tetrachloride	56-23-5	5	5	0.15	0.05	1	0.3	0.1
Chlorobenzene	108-90-7	25	25	2.6	0.8	1	0.5	0.21
Chloroethane (ethyl chloride)	75-00-3	16	16	5.3	1.6	1	0.5	0.21
Chloroform	67-66-3	28	28	0.07	0.02	1	0.3	0.07
Chloromethane	74-87-3	188	188	6.3	1.9	1	0.5	0.25
Dibromo-3-chloropropane, 1, 2-	96-12-8	0.04	0.04	1E-04	3E-05	2	1	0.5
Dibromochloromethane	124-48-1	0.93	0.93	0.29	0.09	1	0.3	0.15
Dibromoethane, 1-2-	106-93-4	0.04	0.04	0.013	0.004	1	0.5	0.2
Dichlorobenzene, 1, 2-	95-50-1	10	10	3	1	1	0.3	0.15
Dichlorobenzene, 1, 3-	541-73-1	5	5	1.7	0.5	1	0.3	0.11
Dichlorobenzene, 1, 4-	106-46-7	5	5	0.16	0.05	1	0.3	0.15
Dichloroethane, 1, 1-	75-34-3	2.8	2.8	0.9	0.3	1	0.3	0.15
Dichloroethane, 1, 2-	107-06-2	5	5	0.06	0.02	1	0.3	0.14
Dichloroethylene, 1, 1-	75-35-4	7	7	2.3	0.7	1	0.5	0.25
Dichloroethylene, 1, 2-cis-	156-59-2	70	70	1.2	0.4	1	0.3	0.15
Dichloroethylene, 1, 2-trans-	156-60-5	100	100	12	4	1	0.3	0.15
Dichloropropane, 1, 2-	78-87-5	5	5	0.27	0.08	1	0.3	0.15
Ethylbenzene	100-41-4	7.3	7.3	0.5	0.2	1	0.5	0.23
Hexachlorobutadiene	87-68-3	0.2	0.2	0.05	0.01	1	0.3	0.15
Methyl Ethyl Ketone	78-93-3	5587	5587	185	56	10	2	0.6
Methyl Isobutyl Ketone	108-10-1	170	170	56	17	10	5	1.9
Methyl tert-Butyl Ether	1634-04-4	5	5	1.7	0.5	1	0.52	0.26
Methylene Chloride	75-09-2	5	5	1.7	0.5	5	1	0.35
Naphthalene	91-20-3	12	12	0.06	0.02	1	0.5	0.25

Matrix: **Groundwater**

Analytical Group: **VOCs and TICs (EPA SW-846 Method 8260)**

						Laboratory-Specific Limits [b]		
Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	LOQ	LOD	DL
Styrene	100-42-5	10	10	3	1	1	0.5	0.25
Tetrachloroethane, 1,1,1,2-	630-20-6	0.61	0.61	0.2	0.06	1	0.3	0.13
Tetrachloroethane, 1,1,2,2-	79-34-5	0.078	0.078	0.03	0.01	1	0.3	0.1
Tetrachloroethylene	127-18-4	5	5	1.4	0.4	1	0.3	0.15
Toluene	108-88-3	9.8	9.8	3.2	1.0	1	0.3	0.15
Trichlorobenzene, 1, 2, 4-	120-82-1	70	70	0.13	0.04	1	0.5	0.21
Trichloroethane, 1, 1, 1-	71-55-6	11	11	3.6	1.1	1	0.5	0.14
Trichloroethane,1, 1, 2-	79-00-5	5	5	0.014	0.004	1	0.5	0.2
Trichloroethylene	79-01-6	5	5	0.09	0.03	1	0.3	0.15
Trichloropropane, 1, 2, 3-	96-18-4	0.6	0.6	3E-04	8E-05	2	1	0.39
Vinyl Chloride	75-01-4	2	2	0.006	0.002	1	0.3	0.15
Xylenes (total)	1330-20-7	13	13	4.3	1.3	2	0.3	0.15
TICs	—	—	—	—	—	—	—	—

Note: All quantities are in microgram per liter (µg/L).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TIC	tentatively identified compound

[a] DOH (2017) EALs: Table D-1a, Groundwater Action Level (Groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Groundwater**

Analytical Group: **SVOCs (EPA SW-846 Method 8270)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
Bis(2-Chloroethyl)Ether	111-44-4	0.014	0.014	0.005	0.001	10	5	2.2
Bis(2-Ethylhexyl)Phthalate	117-81-7	3	3	1	0.3	20	5	2.5
Chloroaniline, P- (4-Chloroaniline)	106-47-8	0.39	0.39	0.12	0.04	10	5	2.5
Chlorophenol, 2-	95-57-8	0.18	0.18	0.06	0.02	10	5	2
Dibromo,1,2- Chloropropane,3-	96-12-8	0.04	0.04	0.01	0.004	2	1	0.5
Dichlorobenzene, 1,2-	95-50-1	10	10	3	1	10	5	1.1
Dichlorobenzene, 1,3-	541-73-1	5	5	2	0.5	10	5	1
Dichlorobenzene, 1,4-	106-46-7	5	5	2	0.5	10	5	1
Dichlorobenzidine, 3, 3-	91-94-1	0.17	0.17	0.04	0.01	10	5	3
Dichlorophenol, 2, 4-	120-83-2	0.3	0.3	0.1	0.03	10	5	2.5
Diethyl Phthalate	84-66-2	210	210	69	21	10	5	2.5
Dimethyl Phthalate	131-11-3	1100	1100	363	110	10	5	2.5
Dimethylphenol, 2, 4-	105-67-9	120	120	12	4	10	5	2.5
Dinitrobenzene, 1,3-	99-65-0	2	2	0.7	0.2	0.5	0.3	0.131
Dinitrophenol, 2, 4-	51-28-5	14	14	1.3	0.4	20	5	1.8
Dinitrotoluene, 2,4-	121-14-2	0.25	0.25	0.08	0.03	20	5	2.5
Dinitrotoluene, 2, 6-	606-20-2	0.052	0.052	0.016	0.005	20	5	2.5
Hexachlorobenzene	118-74-1	3E-04	3E-04	1E-04	3E-05	20	5	2.5
Hexachlorobutadiene	87-68-3	0.2	0.2	0.05	0.01	10	5	0.9
Hexachloroethane	67-72-1	0.4	0.4	0.1	0.03	10	5	0.8
Isophorone	78-59-1	82	82	26	8	10	5	2.5
Nitrobenzene	98-95-3	0.14	0.14	0.05	0.01	10	5	2.1
Pentachlorophenol	87-86-5	1	1	0.014	0.004	10	5	2.1
Phenol	108-95-2	58	58	19	6	10	5	1
Tetrachlorophenol, 2,3,4,6-	58-90-2	1.2	1.2	0.4	0.1	10	5	2.3
Trichlorobenzene, 1,2,4-	120-82-1	70	70	23	7	10	5	1.3
Trichlorophenol, 2, 4, 5-	95-95-4	1.9	1.9	0.6	0.2	10	5	2.3

Matrix: **Groundwater**

Analytical Group: **SVOCs (EPA SW-846 Method 8270)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
Trichlorophenol, 2, 4, 6-	88-06-2	4.9	4.9	0.4	0.1	10	5	2.5
Trinitrobenzene, 1,3,5-	99-35-4	10	10	3	1	0.5	0.3	0.13
TICs	—	—	—	—	—	—	—	—

Note: All quantities are in microgram per liter (μg/L).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TIC	tentatively identified compound

[a] DOH (2017) EALs: Table D-1a, Groundwater Action Level (Groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Groundwater**

Analytical Group: **TPH-g (EPA SW-846 Method 8260 o)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
TPH-g	-3544	297	297	100	30	20	18	8.6

Note: All quantities are in microgram per liter (µg/L).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TPH	total petroleum hydrocarbons
TPH-g	total petroleum hydrocarbons – gasoline range organics (C6-C12)

[a] DOH (2017) EALs: Table D-1a, Groundwater Action Level (Groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Groundwater**

Analytical Group: **TPH-d; TPH-o (EPA SW-846 Method 8015)**

						Laboratory-Specific Limits [b]		
Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	LOQ	LOD	DL
No extract clean up								
TPH-d	-3550	401	401	130	40	320	300	150
TPH-o	-3551	500	500	165	50	320	300	150
Silica Gel Cleanup by EPA SW-846 Method 3630C								
TPH-d	-3550	401	401	130	40	320	300	150
TPH-o	-3551	500	500	165	50	320	300	150

Note: All quantities are in microgram per liter (µg/L).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TIC	tentatively identified compound
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics (C12-C25)
TPH-o	total petroleum hydrocarbons – residual range organics (C25-C40)

[a] DOH (2017) EALs: Table D-1a, Groundwater Action Level (Groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Groundwater**

Analytical Group: **PAHs (EPA SW-846 Method 8270-SIM)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
Acenaphthene	83-32-9	15	15	5	1	0.2	0.1	0.05
Acenaphthylene	208-96-8	13	13	4	1	0.2	0.1	0.05
Anthracene	120-12-7	0.02	0.02	0.007	0.002	0.2	0.1	0.05
Benzo(a)anthracene	56-55-3	0.027	0.027	0.009	0.003	0.2	0.1	0.04
Benzo(g,h,i)perylene	191-24-2	0.13	0.13	0.04	0.01	0.2	0.1	0.04
Benzo(a)pyrene	50-32-8	0.06	0.06	0.008	0.003	0.2	0.1	0.04
Benzo(b)fluoranthene	205-99-2	0.22	0.22	0.07	0.02	0.2	0.1	0.05
Benzo(k)fluoranthene	207-08-9	0.4	0.4	0.13	0.04	0.2	0.1	0.05
Chrysene	218-01-9	1	1	0.3	0.1	0.2	0.1	0.05
Dibenzo(a,h)anthracene	53-70-3	0.022	0.022	0.007	0.002	0.2	0.1	0.05
Fluoranthene	206-44-0	0.8	0.8	0.26	0.08	0.2	0.1	0.04
Fluorene	86-73-7	3.9	3.9	1.3	0.4	0.2	0.1	0.04
Indeno(1,2,3-cd)pyrene	193-39-5	0.095	0.095	0.03	0.01	0.2	0.1	0.05
Methylnaphthalene, 1-	90-12-0	2.1	2.1	04	0.1	0.2	0.1	0.04
Methylnaphthalene, 2-	91-57-6	4.7	4.7	1.2	0.4	0.2	0.1	0.04
Naphthalene	91-20-3	12	12	0.06	0.02	0.2	0.1	0.04
Phenanthrene	85-01-8	2.3	2.3	0.8	0.2	0.2	0.1	0.04
Pyrene	129-00-0	4.6	4.6	1.5	0.5	0.2	0.1	0.04

Note: All quantities are in microgram per liter (µg/L).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PAH	polynuclear aromatic hydrocarbon
PSL	project screening level

[a] DOH (2017) EALs: Table D-1a, Groundwater Action Level (Groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Groundwater**

Analytical Group: **Dioxins/Furans (EPASW-846 Method 8290)**

Analyte	Abbr. Name	CAS Number	TEF	DOH EAL [a]	PSL	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
								EQL	LOD	EDL
Octachlorodibenzo-p-dioxin	OCDD	3268-87-9	0.0003	—	—	3.4	1	250	—	—
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1,2,3,4,6,7,8-HpCDD	35822-46-9	0.01	—	—	0.1	0.03	125	—	—
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,4,7,8-HxCDD	39227-28-6	0.1	—	—	0.1	0.03	125	—	—
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,6,7,8-HxCDD	57653-85-7	0.1	—	—	0.1	0.03	125	—	—
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1,2,3,7,8,9-HxCDD	19408-74-3	0.1	—	—	0.01	0.003	125	—	—
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1,2,3,7,8-PeCDD	40321-76-4	1	—	—	0.01	0.003	125	—	—
2,3,7,8-Tetrachlorodibenzo-p-dioxin	2,3,7,8-TCDD	1746-01-6	1	—	—	0.01	0.003	50	—	—
Octachlorodibenzofuran	OCDF	39001-02-0	0.0003	—	—	0.01	0.003	250	—	—
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1,2,3,4,6,7,8-HpCDF	67562-39-4	0.01	—	—	0.01	0.003	125	—	—
1,2,3,4,7,8,9-Heptachlorodibenzofuran	1,2,3,4,7,8,9-HpCDF	55673-89-7	0.01	—	—	0.01	0.003	125	—	—
1,2,3,4,7,8-Hexachlorodibenzofuran	1,2,3,4,7,8-HxCDF	70648-26-9	0.1	—	—	0.03	0.01	125	—	—
1,2,3,6,7,8-Hexachlorodibenzofuran	1,2,3,6,7,8-HxCDF	57117-44-9	0.1	—	—	0.001	0.0003	125	—	—
1,2,3,7,8,9-Hexachlorodibenzofuran	1,2,3,7,8,9-HxCDF	72918-21-9	0.1	—	—	0.01	0.003	125	—	—
1,2,3,7,8-Pentachlorodibenzofuran	1,2,3,7,8-PeCDF	57117-41-6	0.03	—	—	0.003	0.001	125	—	—
2,3,4,7,8-Pentachlorodibenzofuran	2,3,4,7,8-PeCDF	57117-31-4	0.3	—	—	0.01	0.003	125	—	—
2,3,4,6,7,8-Hexachlorodibenzofuran	2,3,4,6,7,8-HxCDF	60851-34-5	0.1	—	—	0.001	0.0003	125	—	—
2,3,7,8-Tetrachlorodibenzofuran	2,3,7,8-TCDF	51207-31-9	0.1	—	—	3.4	1	50	—	—
Heptachlorodibenzo-p-dioxins (HpCDD), Total	HpCDD	37871-00-4	—	—	—	—	—	—	—	—
Hexachlorodibenzofurans (HxCDF), Total	HxCDF	55684-94-1	—	—	—	—	—	—	—	—
Hexachlorodibenzo-p-dioxins (HxCDD), Total	HxCDD	34465-46-8	—	—	—	—	—	—	—	—
Heptachlorodibenzofurans (HpCDF), Total	HpCDF	38998-75-3	—	—	—	—	—	—	—	—
Pentachlorodibenzo-p-dioxin (PeCDD), Total	PeCDD	36088-22-9	—	—	—	—	—	—	—	—
Pentachlorodibenzofurans (PeCDF), Total	PeCDF	30402-15-4	—	—	—	—	—	—	—	—
Tetrachlorodibenzo-p-dioxin (TCDD), Total	TCDD	41903-57-5	—	—	—	—	—	—	—	—
Tetrachlorodibenzofurans (TCDF), Total	TCDF	55722-27-5	—	—	—	—	—	—	—	—

Matrix: **Groundwater**

Analytical Group: **Dioxins/Furans (EPASW-846 Method 8290)**

Analyte	Abbr. Name	CAS Number	TEF	DOH EAL [a]	PSL	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
								EQL	LOD	EDL
Dioxins and furans as 2,3,7,8-TCDD TEQ [c]	TEQ TCDD	TEQ LOD=0	1	0.003	0.003	0.01	0.003	—	—	—
Dioxins and furans as 2,3,7,8-TCDD TEQ [c]	TEQ TCDD	TEQ LOD=1/2	1	0.003	0.003	0.01	0.003	—	—	—
Dioxins and furans as 2,3,7,8-TCDD TEQ [c]	TEQ TCDD	TEQ LOD = 1	1	0.003	0.003	0.01	0.003	—	—	—

Note: Units in picogram per liter (pg/L).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DOH	Department of Health, State of Hawaii
DL	detection limit
EAL	environmental action level
EDL	estimated detection limit
EQL	estimated quantitation limit
LOD	limit of detection
LOQ	limit of quantitation
PSL	project screening level
TEF	toxicity equivalence factor
TEQ	toxicity equivalent

[a] DOH (2017) EALs: Table D-1a, Groundwater Action Level (Groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

[c] Calculated by using *The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds* (Van den Berg et al. 2006).

Matrix: **Groundwater**

Analytical Group: **General Chemistry (EPA Method 300.0, EPA SW-846 Method 6010, and SM4500-SID)**

Analyte	CAS No.	Laboratory-Specific Limits [a]			
		Units	LOQ	LOD	DL
Anions by EPA Method 300.0					
Bromide	24959-67-9	mg/L	0.5	0.164	0.05
Chloride	16887-00-6	mg/L	1	0.2	0.08
Fluoride	16984-48-8	mg/L	0.1	0.09	0.08
Nitrate	14797-55-8	mg/L	0.5	0.18	0.04
Sulfate	14808-79-8	mg/L	1	0.198	0.09
Cations by EPA SW 846-6010					
Total calcium	7440-70-2	µg/L	1000	75	27.5
Total magnesium	7439-95-4	µg/L	500	30	12.9
Total manganese	7439-96-5	µg/L	10	4	1.23
Total potassium	7440-09-7	µg/L	3000	500	111.1
Total sodium	7440-23-5	µg/L	5000	500	220
Si by Standard Method 4500-SID					
Total silica	7631-86-9	mg/L	1	0.8	0.53
Dissolved silica	7631-86-9	mg/L	1	0.8	0.53

—	not applicable or information not available
µg/L	microgram per liter
CAS	Chemical Abstracts Service
DL	detection limit
LOD	limit of detection
LOQ	limit of quantitation
mg/L	milligram per liter
no.	number

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

Matrix:	**Groundwater**
Analytical Group:	**Natural Attenuation Parameters (NAPs) (EPA 300.0, EPA SW-846-6010, and SM 4500-SID)**

Analyte	CAS No.	Laboratory-Specific Limits [a]			
		Units	LOQ	LOD	DL
Methane by RSK 175					
Methane (CH_4)	74-82-8	µg/L	5	1	0.25
Organic Carbon by EPA 9060					
Total Organic Carbon (TOC)	-221	mg/L	0.93	0.35	0.13
Dissolved Organic Carbon (DOC)	-222	mg/L	0.93	0.35	0.13
Alkalinity by SM 2320					
Total alkalinity	-152	mg/L	2	1.7	0.85
Bicarbonate alkalinity	71-52-3	mg/L	2	1.7	0.85
Carbonate alkalinity	3812-32-6	mg/L	2	1.7	0.85
Nitrogen as Nitrate-nitrite by EPA Method 353.2					
Nitrate-Nitrite Nitrogen	7697-37-2/14797-65-0	mg/L	0.1	0.09	0.028
Ferrous Iron by SM 3500-FeB					
Iron, Ferrous (Fe^{2+})	15438-31-0	mg/L	1	0.32	0.16

—	not applicable or information not available
µg/L	microgram per liter
CAS	Chemical Abstracts Service
DL	detection limit
LOD	limit of detection
LOQ	limit of quantitation
mg/L	milligram per liter
no.	number

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

15.2 SOIL REFERENCE LIMITS

Matrix: **Soil**

Analytical Group: **VOCs (EPA SW-846 Method 8260)**

						Laboratory-Specific Limits [b]		
Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	LOQ	LOD	DL
Acetone	67-64-1	1	1	0.3	0.1	0.01	0.005	0.0025
Benzene	71-43-2	0.3	0.3	0.1	0.03	0.005	0.002	0.0004
Bromodichloromethane	75-27-4	0.0025	0.0025	0.0008	0.0003	0.005	0.002	0.0007
Bromoform	75-25-2	0.69	0.69	0.2	0.07	0.005	0.002	0.0008
Bromomethane	74-83-9	0.22	0.22	0.07	0.02	0.005	0.002	0.0010
Carbon Tetrachloride	56-23-5	0.1	0.1	0.03	0.01	0.005	0.002	0.0008
Chlorobenzene	108-90-7	1.5	1.5	0.5	0.2	0.005	0.002	0.0005
Chloroethane (ethyl chloride)	75-00-3	1.2	1.2	0.4	0.1	0.005	0.002	0.0010
Chloroform	67-66-3	0.026	0.026	0.009	0.003	0.005	0.005	0.0018
Chloromethane	74-87-3	4	4	1.0	0.4	0.01	0.0020	0.0010
Dibromo-3-chloropropane, 1, 2-	96-12-8	0.00081	0.00081	0.0003	0.00008	0.01	0.005	0.0022
Dibromochloromethane	124-48-1	0.0094	0.0094	0.003	0.0009	0.005	0.002	0.0010
Dibromoethane, 1, 2-	106-93-4	0.00042	0.00042	0.0001	0.00004	0.005	0.003	0.002
Dichlorobenzene, 1, 2-	95-50-1	0.75	0.75	0.3	0.08	0.005	0.002	0.0005
Dichlorobenzene, 1, 3-	541-73-1	0.57	0.57	0.2	0.06	0.005	0.002	0.0006
Dichlorobenzene, 1, 4-	106-46-7	0.055	0.055	0.02	0.006	0.005	0.002	0.0007
Dichloroethane, 1, 1-	75-34-3	0.11	0.11	0.04	0.01	0.005	0.002	0.0003
Dichloroethane, 1, 2-	107-06-2	0.023	0.023	0.008	0.002	0.005	0.002	0.0001
Dichloroethylene, 1, 1-	75-35-4	1.2	1.2	0.4	0.1	0.005	0.002	0.0008
Dichloroethylene, 1, 2-cis-	156-59-2	0.36	0.36	0.1	0.04	0.005	0.0020	0.0009
Dichloroethylene, 1, 2-trans-	156-60-5	3.6	3.6	1.0	0.4	0.005	0.0020	0.0010
Dichloropropane, 1, 2-	78-87-5	0.14	0.14	0.05	0.01	0.005	0.002	0.0007
Dichloropropane, 1, 3-	142-28-9	—	—	53	16	0.005	0.002	0.0006
Ethylbenzene	100-41-4	0.9	0.9	0.3	0.09	0.005	0.002	0.0010
Hexachlorobutadiene	87-68-3	0.041	0.041	0.01	0.004	0.01	0.002	0.0010
Methyl Ethyl Ketone	78-93-3	6.2	6.2	2	0.6	0.01	0.003	0.0015
Methyl Isobutyl Ketone	108-10-1	0.5	0.5	0.20	0.05	0.01	0.002	0.0009
Methyl tert-Butyl Ether (MTBE)	1634-04-4	0.028	0.028	0.009	0.003	0.005	0.002	0.0010
Methylene Chloride	75-09-2	0.12	0.12	0.04	0.01	0.02	0.01	0.0006

Matrix: **Soil**

Analytical Group: **VOCs (EPA SW-846 Method 8260)**

						Laboratory-Specific Limits [b]		
Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	LOQ	LOD	DL
Naphthalene	91-20-3	3.1	3.1	1.0	0.3	0.005	0.002	0.0010
Styrene	100-42-5	0.91	0.91	0.3	0.09	0.005	0.002	0.0010
Tetrachloroethane, 1,1,1,2-	630-20-6	0.018	0.018	0.006	0.002	0.005	0.002	0.0006
Tetrachloroethane, 1,1,2,2-	79-34-5	0.0014	0.0014	0.0005	0.0001	0.005	0.002	0.0010
Tetrachloroethylene	127-18-4	0.098	0.098	0.03	0.01	0.005	0.002	0.0005
Toluene	108-88-3	0.78	0.78	0.3	0.1	0.005	0.002	0.0010
Trichlorobenzene, 1, 2, 4-	120-82-1	0.18	0.18	0.06	0.02	0.005	0.002	0.0005
Trichloroethane, 1, 1, 1-	71-55-6	1.2	1.2	0.4	0.1	0.005	0.002	0.0004
Trichloroethane,1, 1, 2-	79-00-5	0.0089	0.0089	0.003	0.001	0.005	0.002	0.0003
Trichloroethylene	79-01-6	0.089	0.089	0.03	0.009	0.005	0.002	0.0009
Trichloropropane, 1, 2, 3-	96-18-4	0.005	0.005	0.002	0.0005	0.005	0.002	0.0009
Vinyl Chloride	75-01-4	0.036	0.036	0.01	0.004	0.005	0.002	0.0010
Xylenes (total)	1330-20-7	1.4	1.4	0.5	0.1	0.01	0.0050	0.0024
TICs	—	—	—	—	—	—	—	—

Note: All quantities are in milligram per kilogram (mg/kg).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TIC	tentatively identified compound

[a] DOH (2017) EALs: Table A-2, Soil Action Level (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site; dry-weight basis).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Soil**

Analytical Group: **SVOCs & TICs (EPA SW-846 Method 8270)**

						Laboratory-Specific Limits [b]		
Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	LOQ	LOD	DL
Bis(2-Chloroethyl)Ether	111-44-4	7.5E-05	7.5E-05	3E-05	8E-06	0.33	0.167	0.05
Bis(2-Ethylhexyl)Phthalate	117-81-7	37	37	12	4	0.33	0.167	0.062
Chloroaniline, P- (4-Chloroaniline)	106-47-8	0.0073	0.0073	0.002	0.0007	0.33	0.167	0.017
Chlorophenol, 2-	95-57-8	0.012	0.012	0.004	0.001	0.33	0.167	0.044
Dibromo,1,2- Chloropropane,3-	96-12-8	0.00081	0.00081	0.0003	0.00008	2.0	1.00	0.50
Dichlorobenzene, 1,2-	95-50-1	0.75	0.75	0.2	0.08	0.33	0.167	0.651
Dichlorobenzene, 1,3-	541-73-1	0.57	0.57	0.2	0.06	0.33	0.167	0.651
Dichlorobenzene, 1,4-	106-46-7	0.055	0.055	0.02	0.006	0.33	0.167	0.049
Dichlorobenzidine, 3, 3-	91-94-1	0.092	0.092	0.03	0.009	0.33	0.167	0.056
Dichlorophenol, 2, 4-	120-83-2	7.3E-03	7.3E-03	2E-03	7E-04	0.33	0.167	0.051
Diethyl Phthalate	84-66-2	3.7	3.7	1	0.4	0.33	0.167	0.062
Dimethyl Phthalate	131-11-3	26	26	8	3	0.33	0.167	0.063
Dimethylphenol, 2, 4-	105-67-9	9.8	9.8	3	1	0.33	0.167	0.044
Dinitrobenzene, 1,3-	99-65-0	0.12	0.12	0.04	0.01	0.45	0.200	0.063
Dinitrophenol, 2, 4-	51-28-5	1.1	1.1	0.4	0.1	0.66	0.167	0.054
Dinitrotoluene, 2,4	121-14-2	0.024	0.024	0.008	0.002	0.66	0.167	0.064
Dinitrotoluene, 2, 6-	606-20-2	5.1E-03	5.1E-03	2E-03	5E-04	0.66	0.167	0.061
Hexachlorobenzene	118-74-1	0.22	0.22	0.07	0.02	0.66	0.167	0.06
Hexachlorobutadiene	87-68-3	0.041	0.041	0.01	0.004	0.33	0.167	0.052
Hexachloroethane	67-72-1	0.023	0.023	0.008	0.002	0.33	0.167	0.05
Isophorone	78-59-1	0.89	0.89	0.3	0.09	0.33	0.167	0.057
Nitrobenzene	98-95-3	5.3E-03	5.3E-03	2E-03	5E-04	0.33	0.167	0.05
Pentachlorophenol	87-86-5	0.098	0.098	0.03	0.01	0.66	0.167	0.059
Phenol	108-95-2	1.8	1.8	0.6	0.2	0.33	0.167	0.043
Tetrachlorophenol, 2,3,4,6-	58-90-2	0.056	0.056	0.02	0.006	0.33	0.167	0.066
Trichlorobenzene, 1,2,4-	120-82-1	0.18	0.18	0.06	0.02	0.33	0.167	0.049

Matrix: **Soil**

Analytical Group: **SVOCs & TICs (EPA SW-846 Method 8270)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
Trichlorophenol, 2, 4, 5-	95-95-4	0.5	0.5	0.2	0.05	0.33	0.167	0.06
Trichlorophenol, 2, 4, 6-	88-06-2	0.31	0.31	0.1	0.03	0.33	0.167	0.048
Trinitrobenzene, 1,3,5-	99-35-4	2.8	2.8	0.9	0.3	0.5	0.2	0.08
TICs	various	—	—	—	—	—	—	—

Note: All quantities are in milligram per kilogram (mg/kg). (dry-weight basis).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TIC	tentatively identified compounds

[a] DOH (2017) EALs: Table A-2, Soil Action Level (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site.

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Soil**

Analytical Group: **PAHs (EPA SW-846 Method 8270-SIM)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
Acenaphthene	83-32-9	118	118	39	12	0.005	0.003	0.001
Acenaphthylene	208-96-8	99.9	99.9	33	10	0.005	0.003	0.0009
Anthracene	120-12-7	4.23	4.23	1	0.4	0.005	0.003	0.0008
Benzo(a)anthracene	56-55-3	9.98	9.98	3	1	0.005	0.003	0.0009
Benzo(g,h,i)perylene	191-24-2	34.5	34.5	11	3	0.005	0.003	0.0013
Benzo(a)pyrene	50-32-8	3.56	3.56	1	0.4	0.005	0.003	0.0009
Benzo(b)fluoranthene	205-99-2	11.3	11.3	4	1	0.005	0.003	0.0011
Benzo(k)fluoranthene	207-08-9	39	39	13	4	0.005	0.003	0.001
Chrysene	218-01-9	30	30	10	3	0.005	0.003	0.0008
Dibenzo(a,h)anthracene	53-70-3	1.13	1.13	0.4	0.1	0.005	0.003	0.0009
Fluoranthene	206-44-0	120	120	40	12	0.005	0.003	0.0012
Fluorene	86-73-7	93.1	93.1	31	9	0.005	0.003	0.001
Indeno(1,2,3-cd)pyrene	193-39-5	11.3	11.3	4	1	0.005	0.003	0.0009
Methylnaphthalene, 1-	90-12-0	4.23	4.23	1	0.4	0.005	0.003	0.001
Methylnaphthalene, 2-	91-57-6	4.15	4.15	1	0.4	0.005	0.003	0.0009
Naphthalene	91-20-3	4.4	4.4	1	0.4	0.005	0.003	0.0009
Phenanthrene	85-01-8	463	463	153	46	0.005	0.003	0.0011
Pyrene	129-00-0	44	44	14	4	0.005	0.003	0.0012

Note: All quantities are in milligram per kilogram (mg/kg).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PAH	polynuclear aromatic hydrocarbon
PSL	project screening level

[a] DOH (2017) EALs: Table A-2, Soil Action Level (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site; dry-weight basis).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Soil**

Analytical Group: **TPH-g (EPA SW-846 Method 8260)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
TPH-g	—	100	100	30	10	0.02	0.015	0.0061

Note: All quantities are in mg/kg.

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TPH	total petroleum hydrocarbons
TPH-g	total petroleum hydrocarbons – gasoline range organics (C6-C12)

[a] DOH (2017) EALs: Table A-2, Soil Action Level (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site; dry-weight basis).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Soil**

Analytical Group: **TPH-d; TPH-o (EPA SW-846 Method 8015)**

Analyte	CAS No.	DOH EAL [a]	PSL [a]	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
						LOQ	LOD	DL
TPH-d	-3550	219	219	73	22	5	1	0.5
TPH-o	-3551	500	500	165	50	50	10	3.5

Note: All quantities are in mg/kg.

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
no.	number
PSL	project screening level
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics (C12-C25)
TPH-o	total petroleum hydrocarbons – residual range organics (C25-C40)

[a] DOH (2017) EALs: Table A-2, Soil Action Level (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site; dry-weight basis).

[b] Laboratory-specific LOQs, LODs, and DLs are limits that an individual laboratory can achieve when performing a specific analytical method.

Matrix: **Soil**

Analytical Group: **Dioxins/Furans (EPASW-846 Method 8290)**

Analyte	Abbr. Name	CAS Number	TEF	DOH EAL [a]	PSL	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
								EQL	LOD	EDL
Octachlorodibenzo-p-dioxin	OCDD	3268-87-9	0.0003	—	—	5280	1600	25	—	—
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	1,2,3,4,6,7,8-HpCDD	35822-46-9	0.01	—	—	158	48	12.5	—	—
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,4,7,8-HxCDD	39227-28-6	0.1	—	—	16	5	12.5	—	—
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	1,2,3,6,7,8-HxCDD	57653-85-7	0.1	—	—	16	5	12.5	—	—
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	1,2,3,7,8,9-HxCDD	19408-74-3	0.1	—	—	16	5	12.5	—	—
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	1,2,3,7,8-PeCDD	40321-76-4	1	—	—	1.6	0.5	12.5	—	—
2,3,7,8-Tetrachlorodibenzo-p-dioxin	2,3,7,8-TCDD	1746-01-6	1	—	—	1.6	0.5	5	—	—
Octachlorodibenzofuran	OCDF	39001-02-0	0.0003	—	—	5280	1600	25	—	—
1,2,3,4,6,7,8-Heptachlorodibenzofuran	1,2,3,4,6,7,8-HpCDF	67562-39-4	0.01	—	—	158	48	12.5	—	—
1,2,3,4,7,8,9-Heptachlorodibenzofuran	1,2,3,4,7,8,9-HpCDF	55673-89-7	0.01	—	—	158	48	12.5	—	—
1,2,3,4,7,8-Hexachlorodibenzofuran	1,2,3,4,7,8-HxCDF	70648-26-9	0.1	—	—	16	5	12.5	—	—
1,2,3,6,7,8-Hexachlorodibenzofuran	1,2,3,6,7,8-HxCDF	57117-44-9	0.1	—	—	16	5	12.5	—	—
1,2,3,7,8,9-Hexachlorodibenzofuran	1,2,3,7,8,9-HxCDF	72918-21-9	0.1	—	—	16	5	12.5	—	—
1,2,3,7,8-Pentachlorodibenzofuran	1,2,3,7,8-PeCDF	57117-41-6	0.03	—	—	5	2	12.5	—	—
2,3,4,7,8-Pentachlorodibenzofuran	2,3,4,7,8-PeCDF	57117-31-4	0.3	—	—	53	16	12.5	—	—
2,3,4,6,7,8-Hexachlorodibenzofuran	2,3,4,6,7,8-HxCDF	60851-34-5	0.1	—	—	16	5	12.5	—	—
2,3,7,8-Tetrachlorodibenzofuran	2,3,7,8-TCDF	51207-31-9	0.1	—	—	16	5	5	—	—
Heptachlorodibenzo-p-dioxins (HpCDD), Total	HpCDD	37871-00-4	—	—	—	—	—	—	—	—
Hexachlorodibenzofurans (HxCDF), Total	HxCDF	55684-94-1	—	—	—	—	—	—	—	—
Hexachlorodibenzo-p-dioxins (HxCDD), Total	HxCDD	34465-46-8	—	—	—	33	10	—	—	—
Heptachlorodibenzofurans (HpCDF), Total	HpCDF	38998-75-3	—	—	—	—	—	—	—	—
Pentachlorodibenzo-p-dioxin (PeCDD), Total	PeCDD	36088-22-9	—	—	—	—	—	—	—	—
Pentachlorodibenzofurans (PeCDF), Total	PeCDF	30402-15-4	—	—	—	—	—	—	—	—
Tetrachlorodibenzo-p-dioxin (TCDD), Total	TCDD	41903-57-5	—	—	—	—	—	—	—	—
Tetrachlorodibenzofurans (TCDF), Total	TCDF	55722-27-5	—	—	—	—	—	—	—	—
Dioxins and furans as 2,3,7,8-TCDD TEQ	TEQ TCDD	TEQ ND=0	1	240	240	3	0.5	—	—	—

Matrix: **Soil**

Analytical Group: **Dioxins/Furans (EPASW-846 Method 8290)**

Analyte	Abbr. Name	CAS Number	TEF	DOH EAL [a]	PSL	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits [b]		
								EQL	LOD	EDL
Dioxins and furans as 2,3,7,8-TCDD TEQ	TEQ TCDD	TEQ ND=1/2	1	240	240	3	0.5	—	—	—
Dioxins and furans as 2,3,7,8-TCDD TEQ	TEQ TCDD	TEQ ND = 1	1	240	240	3	0.5	—	—	—

Note: Units in picogram per gram (pg/g).

—	not applicable or information not available
CAS	Chemical Abstracts Service
DL	detection limit
EAL	environmental action level
LOD	limit of detection
LOQ	limit of quantitation
PSL	project screening level
TEF	toxicity equivalence factor
TEQ	toxicity equivalent

[a] DOH (2017) EALs: Table A-2, Soil Action Level (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site; dry-weight basis).

[b] Toxicity equivalency factors (TEFs) are used to determine a screening value for the dioxin and furan congeners by multiplying the TEF by the 2,3,4,5-TCDD screening criteria, TEQ is calculated using with 2005 WHO TEFs (Van den Berg et al. 2006).

Matrix: **Soil**

Analytical Group: **Soil Geotechnical and Chemistry**

Characterization	Method Reference
Atterberg Limits	ASTM D4318
Particle Size Distribution	ASTM D422
Soil Classification	ASTM D2488
Moisture Content and Density	ASTM D27263B or D2937
Total Porosity	ASTM D6836M or API RP40
Total Organic Carbon	Walkley-Black Method
pH	EPA 9045D or ASTM G51
Cation Exchange Capacity	EPA 9081
Moisture Content	ASTM D7263B

API	American Petroleum Institute
ASTM	ASTM International
EPA	Environmental Protection Agency, United States

Worksheet #16: Project Schedule/Timeline Table

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date [b]
Prepare and submit Draft WP and APP	AECOM	February 14, 2020	July 3, 2020	Draft WP and APP	July 3, 2020
Government review and comment of Draft WP and APP	NAVFAC Hawaii/ DOH/EPA	July 4, 2020	January 27, 2021	N/A	N/A
Prepare and submit Final WP and APP	AECOM	January 27, 2021	February 10, 2020	Final WP and APP	February 10, 2020
Field investigation (sample/data collection)	AECOM	February 8, 2021	August 5, 2022	N/A	N/A
Perform IDW management and disposal	AECOM	June 19, 2021	September 21, 2022	IDW Disposal Letter	September 21, 2022
Perform data validation and evaluation	AECOM	February 8, 2021	August 5, 2022	N/A	N/A
Prepare and submit In-Progress Draft SA Report	AECOM	August 5, 2022	November 2, 2022	In-Progress Draft SA Report	November 2, 2022
Government review & comment of In-Progress Draft SA Report	NAVFAC Hawaii	November 2, 2022	November 16, 2022	N/A	N/A
Prepare and submit Draft SA Report	AECOM	November 25, 2022	February 10, 2023	Draft SA Report	February 10, 2023
Government review and comment of Draft SA Report	NAVFAC Hawaii/ DOH/EPA	February 10, 2023	March 12, 2023	N/A	N/A
Prepare and submit Final SA Report	AECOM	March 19, 2023	April 21, 2023	Final SA Report	April 21, 2023
Prepare and submit Draft RAB Package (SA Findings) [a]	AECOM	April 21, 2023	May 6, 2023	Draft RAB Presentation and Fact Sheet	May 6, 2023
Government review and comment on Draft RAB Package [a]	NAVFAC Hawaii	May 6, 2023	May 13, 2023	N/A	N/A
Prepare and submit Final RAB Package (SA Findings) [a]	AECOM	May 13, 2023	May 31, 2023	Final RAB Presentation and Fact Sheet	May 31, 2023

AECOM	AECOM Technical Services, Inc.
APP	accident prevention plan
HI	Hawaii
IDW	investigation-derived waste
N/A	not applicable
NAVFAC	Naval Facilities Engineering Systems Command
RAB	Restoration Advisory Board
SA	Site Assessment
WP	work plan

[a] RAB meeting dates are contingent on the ability to hold meetings based on current local and federal guidance for public gatherings.
[b] Assumes timely government review and provision of comments.

Worksheet #17: Sampling Design and Rationale

This worksheet describes the proposed sampling design and rationale, based on the site history and available data. Following the 1990s Oily Waste Disposal Facility (OWDF) removal action and remedial investigation (RI), all site monitoring wells except for MW08 (which is currently labelled OWDFMW01) were abandoned and sealed. In 2009, OWDFMW01 was incorporated into the Navy's Red Hill groundwater long-term monitoring (LTM) program. The LTM data is summarized as follows: TPH-d concentrations over time at OWDFMW01 and other Red Hill monitoring wells are presented on WP Supplement Figure 13; Appendix D presents a table of cumulative historical groundwater results for OWDFMW01 collected during the LTM program; and WP Supplement Figure 15 presents select chromatograms of organic material reported as total petroleum hydrocarbons (TPH)-diesel range organics (TPH-d) in several area groundwater samples in 2015. As discussed in Section 10.1.10, above, the composition and source of the sporadic TPH-d detections in OWDFMW01 during LTM are unknown. The lateral extent of TPH in groundwater in the vicinity of OWDFMW01 is also unknown. Consequently, this sampling design was developed to re-evaluate the nature, extent, and source of TPH in the basal groundwater, conduct an environmental health evaluation, and evaluate whether any response actions are recommended.

Thus, because the primary potential exposure route is through the drinking water source underlying the OWDF, the field investigation will concentrate on evaluating the basal groundwater pathway (including chemical of potential concern [COPC] impacts, geochemical parameters, and flow and transport regimes) by advancing several new borings, completing them as seven monitoring well clusters screened in both perched and basal aquifers, analyzing soil and groundwater samples, and conducting hydraulic studies. WP Supplement Figure 16 displays the proposed location of the well clusters, which are further discussed in the following section.

17.1 MONITORING WELL INSTALLATION

The proposed cluster locations were chosen based on the following considerations:

- OWDFMW02 and OWDFMW03 straddle the former disposal pit, which was determined to be the primary onsite historical source area, to investigate whether groundwater near the former pit is impacted. OWDFMW02 is expected to be downgradient from the disposal pit during supply well pumping conditions, while OWDFMW03 may be downgradient when the supply well is off for extended periods.
  - In addition, OWDFMW02 is located relatively close to OWDFMW01 in order to evaluate whether the anomalous groundwater chemistry (i.e., TPH detections and elevated pH) in the vicinity of OWDFMW01 is localized or extends towards the former pit.
- OWDFMW04 is located between well OWDFMW01 (and the former pit) and the Red Hill Shaft to confirm that contamination is not migrating towards the primary exposure point and to better evaluate groundwater flow patterns between the OWDF and the Red Hill Shaft.
- OWDFMW05, OWDFMW06, OWDFMW07, and OWDFMW08 are positioned near the borders of the OWDF, to further evaluate groundwater flow patterns around the OWDF and to investigate whether there is any evidence of contamination being transported to or from neighboring properties such as those at the Halawa Industrial Park or the State of Hawaii Department of Agriculture Animal Quarantine Station.

Each well cluster may include the following individual wells:

- Each cluster will include one "deep" well in the basal aquifer, which was encountered under confined conditions beneath a layer of massive basalt, the bottom of which (and basal groundwater) was encountered at approximately -1 to -20 feet (ft) mean sea level (msl) during the RI (DON 2000).
- Most of the clusters are expected to include one "shallow" well in the first perched aquifer, which was encountered throughout most of the site during the RI at elevations ranging from approximately 86 to 104 ft msl (DON 1996a). An exception is OWDFMW04, which may not encounter a perched aquifer, in which case it will not have a shallow well.
- If, in any given cluster location, a second perched zone is encountered between the uppermost perched aquifer and the underlying basal aquifer, another well may be installed in the second perched aquifer.

Thus, there is some uncertainty regarding how many wells will be installed: the seven proposed well clusters could include a total of between seven wells (in the unlikely event that no perched aquifer is encountered) and up to twenty one wells (in the unlikely event that two perched zones are encountered in each cluster location). For planning purposes, based on available data from the RI, it is assumed that location OWDFMW04 will not encounter perched water, and all of the seven other new well cluster locations will include both one deep and one shallow well, for an anticipated total of 13 new wells.

It is anticipated that perched aquifers will be less than 10 feet thick, and the basal aquifer is likely to be confined by a 20- to 50-ft thick layer of massive basalt. Therefore, perched wells will be screened from five feet above the perched water table to the underlying aquitard, with a minimum total of 10 feet of screen; and basal wells in confined conditions will have 20-ft screens, with the tops of the screens located at the bottom of the confining layer. To protect the basal aquifer, basal wells will be installed within conductor casing extending from the ground surface to the top of the confining layer, which is expected to be located approximately 20 ft msl in most locations.

Gyroscopic field surveys will be conducted at basal monitoring wells to obtain true vertical depth data. These surveys will allow for three-dimensional modeling of gyroscopic data to determine if any of the wells deviate from true vertical and, if deviations occur, to calculate correction factors that can be applied to groundwater level measurements for true vertical depths.

Each monitoring well location will be surveyed via Second Order, Class I Leveling Survey techniques by a registered land surveyor to determine the elevation of the ground surface and water level reference point to an accuracy of 0.01 ft. Each monitoring well location will be surveyed using differential Global Positioning System (GPS) methods to determine the precise horizontal location within 0.10 ft.

17.2 GROUNDWATER SAMPLING AND ANALYSIS

Four rounds of quarterly groundwater sampling will be conducted after installation of the new monitoring wells. Each event will include the collection of one sample from existing well OWDFMW01 and one sample from each of the new wells (for an anticipated total of 14 primary samples during each quarterly sampling event). The groundwater samples will be collected to evaluate the nature and extent of COPCs that may have migrated to and impacted groundwater, as well as natural attenuation and aquifer chemistry parameters. Groundwater samples will be collected in accordance with Project Procedure I-C-3, *Monitoring Well Sampling* (DON 2015), using a dedicated bladder pump. Detailed information regarding the laboratory analysis of COPCs is presented in Table 11-2 and Worksheet #15; sample management is presented in Section 17.6.

In addition, this investigation was motivated by laboratory results reported as "TPH" from the RHSF LTM program. While TPH results can effectively measure the total concentration of hydrocarbons within the reporting range of the specific test under the particular procedure employed, these data do not provide information on the composition of the hydrocarbons or whether any material originating from petroleum fuel is present and, if so, whether it has undergone or is undergoing natural attenuation. Therefore, in order to further assess hydrocarbon composition and biodegradation in the groundwater, natural attenuation parameters (NAPs) will be analyzed to assess whether natural attenuation is occurring on site; and those groundwater samples with detectable concentrations of TPH-d or TPH-o will be further analyzed for TPH using silica gel cleanup (SGC) to determine the fraction of polar and non-polar hydrocarbons:

- *Natural Attenuation Parameters:* Fuel hydrocarbons can be biodegraded by microorganisms in the subsurface under aerobic or anaerobic conditions, part of the process referred to as natural attenuation. The progression of natural attenuation at a site via aerobic and anaerobic decomposition can be evaluated through the analysis of NAPs.

  Aerobic biodegradation is the result of microbial-mediated redox reactions in which coupling of oxidation of an electron donor and reduction of an electron acceptor occurs. During aerobic biodegradation of hydrocarbons, dissolved oxygen (DO) concentrations are depleted as aerobic respiration occurs because DO is the most thermodynamically favored electron acceptor used in biodegradation. For aerobic biodegradation to occur, subsurface conditions must be suitable for bacterial degradation of fuel hydrocarbons. These conditions include the presence of microbes (e.g., bacteria, yeast, and fungi) capable of metabolizing hydrocarbons, the availability of oxygen and nutrients in the subsurface to facilitate metabolism of hydrocarbons, warm subsurface temperatures and neutral pH conditions, the presence of amendable hydrocarbons at suitable concentrations, and sufficient surface area to promote reactions.

  In anaerobic biodegradation of hydrocarbons, reactions occur in low oxygen environments (e.g., after aerobic biodegradation has occurred). Potential electron acceptors include nitrate, ferric iron, sulfate, and carbon dioxide. Use of the electron acceptors proceeds along a natural succession in the order listed above because of decreasing thermodynamic efficiency (Leeson et al. 2004). Nitrate is the most favored electron acceptor of the anaerobic pathways, biodegrading to nitrite (followed by nitrogen gas) and carbon dioxide. Ferric iron in soil can be consumed by anaerobic biodegradation when both DO and nitrate have been depleted in anaerobic groundwater, yielding dissolved ferrous iron in groundwater. Sulfate can be consumed by anaerobic degradation after DO, nitrate, and ferric iron are depleted, yielding precipitated iron sulfides. Lower concentrations of sulfate in groundwater compared to background levels indicate that sulfate reduction is an ongoing biological process for petroleum hydrocarbon degradation within plume areas. When all of the soluble electron acceptors (i.e., DO, nitrate, ferric iron, and sulfate) are depleted, groundwater conditions become conducive to fermentation and methane is generated by methanogenesis. Thus, NAPs can be used to characterize natural attenuation and biodegradation processes.

- *Silica Gel Cleanup:* The refining process used to create fuel products largely eliminates any polar compounds that are naturally present in crude oil (Zemo, Synowiec, et al. 2013). After petroleum product is released to the environment, biological activity (sometimes referred to as "weathering" or "degradation") creates polar hydrocarbons as a by-product. Laboratory

TPH results, however, do not distinguish between petroleum hydrocarbons and non-petroleum hydrocarbons, nor do they distinguish between polar and nonpolar fractions of petroleum-related hydrocarbons. Because polar compounds preferentially adsorb to silica, while nonpolar compounds do not, SGC can be used to separate polar from nonpolar hydrocarbons in order to analyze "TPH" concentrations of the nonpolar fraction, which is typically associated with unweathered petroleum fuel. DOH TGM Section 9.3.1.2, *Total Petroleum Hydrocarbons*, discusses the use of SGC to compare the remaining nonpolar TPH fraction to the total amount of hydrocarbons within the range of the test, as an indicator of biodegradation: "Comparison of data for groundwater samples tested with and without silica gel cleanup could be useful for assessing the state of natural biodegradation within a plume of petroleum-contaminated groundwater and optimizing remedial and monitoring actions" (DOH 2018). Therefore, SGC will be performed for all groundwater samples that have detectable concentrations of TPH-d or TPH-o. Comparing SGC TPH results to standard TPH results allows calculation of the ratio of nonpolar hydrocarbons (i.e., unweathered petroleum) to polar hydrocarbons (i.e., from weathered petroleum or non-petroleum sources). This data may indicate the presence of non-petroleum hydrocarbons, which would be consistent with the OWDFMW01 TPH chromatograms from the LTM program, and also, like the NAP data, may provide an additional line of evidence regarding whether attenuation is occurring naturally in the subsurface.

17.3 WATER LEVEL STUDY

After all of the new well clusters are installed and developed, a basal groundwater elevation study will be conducted to evaluate groundwater flow in the basal aquifer in and around the vicinity of the OWDF and the Red Hill Shaft. Synoptic groundwater level data will be collected over the course of the one-year groundwater monitoring program, using transducers installed in up to eight monitoring locations within and around the OWDF, including the new basal wells and existing well OWDFMW01. Data collection will be coordinated with pumping schedules at Red Hill Shaft, where possible, ideally recording variations in groundwater potentiometric surfaces in response to changing pumping conditions.

17.4 SOIL SAMPLING

During the installation of new groundwater monitoring wells, select subsurface soil samples will be collected from borings to evaluate characteristics that may influence contaminant fate and transport to the basal aquifer, and also to investigate the possible presence of COPCs, if indicated by observations or other field methods. Based on former activities at the site, including the Removal Action, the RI, and other soil investigations discussed in Worksheet #10, surface soil sampling and subsurface delineation of COPCs is not proposed.

Up to three subsurface soil samples, plus quality assurance/quality control (QA/QC) samples, will be collected from each boring in accordance with Naval Facilities Engineering Systems Command (NAVFAC), Pacific Environmental Restoration Program Project Procedure I-B-1, *Soil Sampling* (DON 2015), from the following locations, based on the field manager's discretion and depending on field conditions in each boring:

- The capillary fringes of unconfined perched and basal aquifers, where present.
- The top of aquitards underlying perched aquifers.
- Areas where field observations suggest the potential for contamination.

Soil samples will be inspected, photographed, and characterized in the field. A lithologic description of the soil at each soil boring will be recorded in accordance with Project Procedure I-E, *Soil and Rock Classification* (DON 2015). Characteristics to be recorded on soil sampling logs include: Unified Soil Classification System (USCS); color; soil grain size classification (by percent); moisture content; structure; particle shape, angularity, and maximum size; plasticity of fines; and odor or staining. Analytical parameters for the soil samples are presented in Table 11-2; sample management is presented in Section 17.6. In addition, continuous rock cores will be collected as the boreholes are advanced through the basaltic bedrock to allow for detailed logging and analysis of rock properties.

17.5 FIELD DATA LOGS

All sample information will be transcribed into a field logbook and/or onto field data sheets. Field data sheets will be e-mailed to the project management team each day to track progress.

17.6 ANALYTICAL LABORATORY SAMPLE MANAGEMENT

The sample matrix, number of samples, and number and type of laboratory quality assurance and quality control samples are summarized in Table 11-2. Details on the analytical group, sample volumes, sample container specifications, preservation requirements, and maximum holding times are identified in Worksheets #19 and #20.

The laboratory will provide full electronic data deliverable files, portable document format files of the data deliverables for all project data, and a hard copy of data deliverables for all results including results from secondary subcontract laboratories. Designated samples will be used to obtain necessary subsamples for laboratory QC measurements (i.e., analytical sample duplicate and sample matrix spike/matrix spike duplicate [MS/MSD] pairs). Tasks will be completed using the laboratory standard operating procedures (SOPs). Data verification and validation will be performed as described in Worksheets #34-36.

Analytical data will be uploaded to the Naval Installation Restoration Information Solution system prior to the close of the project. Analytical laboratory reports will be archived at the Federal Records Center. All other data generated in the field and reports generated for the project will be stored as computer-readable data files by AECOM in the Honolulu, Hawaii, office.

Worksheet #18: Location-Specific Sampling Methods/SOP Requirements Table

Sampling Location/ID Number	Matrix	Depth	Analytical Group	Number of Samples [a]	Sampling SOP Reference [b]
OWDFMW02 (A&B) OWDFMW03 (A&B) OWDFMW04 (A) OWDFMW05 (A&B) OWDFMW06 (A&B) OWDFMW07 (A&B) OWDFMW08 (A&B)	Subsurface soil	At the capillary fringe of each perched and basal aquifer [c] At the top of each aquitard underlying each perched aquifer [c] At evidence of observed contamination [b]	VOCs & TICs TPH-g TPH-d TPH-o SVOCs & TICs PAHs Dioxins/Furans	39 normal samples 7 duplicates 7 MS/MSD 7 field blank 7 equipment blank 39 trip blanks	I-B-1, *Soil Sampling*
		Above the capillary fringe	Atterberg limits Grain size distribution Soil classification Moisture content & density Effective porosity & permeability TOC pH Cation exchange capacity	13 samples	I-B-1, *Soil Sampling*
OWDFMW01 OWDFMW02 (A&B) OWDFMW03 (A&B) OWDFMW04 (A) OWDFMW05 (A&B) OWDFMW06 (A&B) OWDFMW07 (A&B) OWDFMW08 (A&B)	Groundwater	Top 10 feet of water table	VOCs & TICs TPH-g TPH-d TPH-o SVOCs & TICs PAHs Dioxins/Furans	56 normal samples 8 duplicate 4 MS/MSD 4 field blank 4 equipment blank 56 trip blanks	I-C-3, *Monitoring Well Sampling*
OWDFMW01 OWDFMW02 (A&B) OWDFMW03 (A&B) OWDFMW04 (A) OWDFMW05 (A&B) OWDFMW06 (A&B) OWDFMW07 (A&B) OWDFMW08 (A&B)	Groundwater	Top 10 feet of water table	Anions Cations Silica Methane Organic carbon Alkalinity Nitrate-Nitrate Nitrogen Ferrous Iron TPH-d & TPH-o with Silica Gel Cleanup [d]	56 samples	I-C-3, *Monitoring Well Sampling*
Based on field observations from each boring and MW	NAPL/Sheen	At evidence of observed NAPL/Sheen [b]	Fingerprinting/Detailed Hydrocarbon Analysis and Evaluation	5 samples [c]	I-C-3, *Monitoring Well Sampling* Sheen sampling procedure (Section 14.4.5)

A	basal aquifer monitoring well
B	perched aquifer monitoring well
ID	identification
MS	matrix spike
MSD	matrix spike duplicate
MW	monitoring well
OWDF	Oily Waste Disposal Facility
PAH	polynuclear aromatic hydrocarbon
SOP	standard operating procedure
SVOC	semivolatile organic compound
TIC	tentatively identified compound
TOC	total organic carbon
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics
VOC	volatile organic compound

[a] Duplicate samples based on 10% of analytical samples per sampling event. MS/MSD samples based on 5% of analytical samples per sampling event. Equipment rinsate blanks based on 1 per event or alternatively they will be collected above 5% of analytical samples per sampling event. One field blank per water source. One trip blank per shipping cooler, actual trip blank analyses may differ from planned.

[b] SOP or worksheet that describes the sample collection procedures.

[c] Estimated sample counts actual number will be determined in the field and based on evaluation of data.

[d] Number of samples analyzed for TPH-d and TPH-o with silica gel cleanup will be contingent on positive detections of TPH-d and TPH-o in non-silica-gel-cleaned samples.

Worksheet #19: Field Sampling Requirements Table

19.1 SOIL

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Soil (Subsurface) by Discrete Sampling						
Subsurface Soil [a] (discrete)	Percent Moisture	Preparation Method: EPA 8000C Preparation SOP: ANAISM02-02 Analysis Method: EPA 8000C Analysis SOP: ANAISM02-02	2 × 32 oz wide-mouth glass, Teflon-lined lid, per decision unit	50 g	Cool to ≤6°C	No maximum holding time.
	VOCs & TICs, TPH-g	Preparation Method: EPA 5035 Preparation SOP: ANA8260 Analysis Method: EPA 8260B Analysis SOP: ANA8260	2 × 40 mL VOA vial [b] with 5 mL DI water and magnetic stir bar and 1 – 40 mL VOA vial [b] with 5 mL methanol	5 g per VOA vial	Frozen or Cool to ≤6°C	14 days when shipped to laboratory within 48 hours at <6°C and frozen (-12°C) upon receipt. If not frozen, samples are to be analyzed immediately.
	TPH-d/TPH-o	Preparation Method: EPA 3550C Preparation SOP: SON01 Analysis Method: EPA 8015B Analysis SOP: ANA8015	2 – 6-inch × 2-inch stainless steel sleeves per sample location	50 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
	SVOCs	Preparation Method: EPA 3550C Preparation SOP: SON001 Analysis Method: EPA 8270D Analysis SOP: ANA8270	2 – 6-inch × 2-inch stainless steel sleeves per sample location	30 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction. [c]
	PAHs	Preparation Method: EPA 3550C Preparation SOP: SON001 Analysis Method: EPA 8270DSIM Analysis SOP: ANA8270SIM	2 – 6-inch × 2-inch stainless steel sleeves per sample location	30 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
	Dioxins/Furans (PCDDs/PCDFs)	Preparation Method: EPA 8290A Preparation SOP: HPL8290 Analysis Method: EPA 8290A Analysis SOP: HPL8290	2 – 6-inch × 2-inch stainless steel sleeves per sample location	10 g	Store in dark Cool to ≤6°C	Samples extracted within 30 days and extracts analyzed within 45 days following extraction.

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Miscellaneous						
Soil Chemistry	pH	Preparation Method: EPA 9040C Preparation SOP: ANA9040 Analysis Method: EPA 9040C Analysis SOP: ANA9040	4-oz glass	20 g	Cool to ≤6°C	Analyze immediately.
	TOC	Preparation Method Walkley-Black Preparation SOP: ANAWalkleyBlk Analysis Method: Walkley-Black Analysis SOP: ANAWalkleyBlk	4-oz glass	100 grams	Cool to ≤ 4°C ± 2°C; protect from sunlight and atmospheric oxygen	Analyze within 28 days.
	CEC	Preparation Method: EPA 9081 Preparation SOP: ANA9081 Analysis Method: EPA 9081 Analysis SOP: ANA9081	4-oz glass	6g	None	6 months.
Geotechnical	Moisture Content	Analysis Method: ASTM D2216 [d] Analysis SOP: ASTM D2216	Ziploc bag	500 g	N/A	N/A.
	Soil Classification	Analysis Method: ASTM D 2488 Analysis SOP: ASTM D2488	Ziploc bag	1 kg	N/A	N/A.
	Grain Size	Analysis Method: ASTM D422 [e] Analysis SOP: ASTM D422	Ziploc or bulk bag sample	1 kg	N/A	N/A.
	Hydraulic Conductivity/ Effective Porosity and Permeability	Analysis Method: ASTM D 5084 Analysis SOP: ASTM D 5084	Bulk bag sample	1 kg	N/A	N/A.
	Atterberg Limits	Analysis Method: ASTM D4318 Analysis SOP: ASTM D4318	Ziploc bag	500 g	N/A	N/A.

°C	degree Celsius
ASTM	ASTM International
DI	deionized
EPA	Environmental Protection Agency, United States
g	gram
H_2SO_4	sulfuric acid
HCl	hydrogen chloride
HNO_3	nitric acid
kg	kilogram
L	liter
mL	milliliter
N/A	not applicable
$NaHSO_4$	sodium bisulfate
oz	ounce
PAH	polynuclear aromatic hydrocarbon
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-p-furan
PSD	particle size distribution
PSG	passive soil gas
SIM	selective ion monitoring
SOP	standard operating procedure
SVOC	semivolatile organic compound
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics
VOA	volatile organic analyte
VOC	volatile organic compound

[a] Sample results will be reported on a dry weight basis.

[b] Pre-tared VOA vial.

[c] This corresponds to requirements for semivolatile organic compound analysis; however, holding times for prepared dioxins samples may be as high as a year.

[d] ASTM D2216 is for moisture content only.

[e] ASTM D422: Amount of sample needed depends on the maximum particle size within the sample itself. For maximum grain size of 3 inch – 5,000 grams are needed. For maximum grain size of 4.75 millimeters – 500 grams are needed.

19.2 WATER

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Water	TPH-g, VOCs & TICs	Preparation Method: EPA 5030B Preparation SOP: ANA8260 Analysis Method: EPA 8260C Analysis SOP: ANA8260	5 × 40-mL vials, Teflon-lined septum caps	40 mL	No headspace, cool to ≤6°C and adjust to pH <2 with H_2SO_4, HCl, or solid $NaHSO_4$	Maximum holding time is 7 days if pH >2 or 14 days if pH <2.
	TPH-d, TPH-o	Preparation Method: EPA 3520C Preparation SOP: LIQ001 Analysis Method: EPA 8015B Analysis SOP: ANA8015	2 × 1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
	TPH-d, TPH-o with Silica Gel Cleanup	Preparation Method: EPA 3520C/EPA 3630 Preparation SOP: LIQ001/CLN004 Analysis Method: EPA 8015B Analysis SOP: ANA8015	2 × 1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
	SVOCs & TICs	Preparation Method: EPA 3520C Preparation SOP: LIQ001 Analysis Method: EPA 8270D Analysis SOP: ANA8270	2 × 1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
	PAHs	Preparation Method: EPA 3520C Preparation SOP: LIQ001 Analysis Method: EPA 8270D SIM Analysis SOP: ANA8270SIM	2 × 1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
	Dioxins/Furnas (PCDDs/PCDFs)	Preparation Method: EPA 8290A Preparation SOP: HPL8092 Analysis Method: EPA 8290A Analysis SOP: HPL8092	2 × 1-L amber glass, Teflon lined lid	1 L	Store in dark Cool to ≤6°C	Samples extracted within 30 days and extracts analyzed within 45 days following extraction
	Methane	Preparation Method: RSK 175M Preparation SOP: ANA RSK175 Analysis Method: RSK 175M Analysis SOP: ANA RSK175	3 × 40-mL vials, Teflon-lined septum caps	40 mL	No headspace, cool to ≤6°C and adjust to pH <2 with HCl	14 days.
	Ferrous Iron	Preparation Method: SM 3500-Fe Preparation SOP: ANA3500FeBc Analysis Method: SM 3500 Analysis SOP: ANA3500FeBc	1 × 250 mL brown plastic	250 mL	Field filtered and adjust to pH <2 with HCl or H_2SO_4, and cool to ≤6°C and no headspace	7 days.
	Nitrate, Sulfate, Chloride, Bromide, Fluoride	Preparation Method: EPA 353.2 Preparation SOP: ANA353.2 Analysis Method: EPA 353.2 Analysis SOP: ANA 353.2	1 × 250 mL plastic	250 mL	Cool to ≤6°C	48 hours (nitrate) 28 days (sulfate, chloride, bromide, and fluoride).
	Nitrate-Nitrite as Nitrogen	Preparation Method: EPA 353.2 Preparation SOP: ANA353.2 Analysis Method: EPA 353.2 Analysis SOP: ANA 353.2	1 × 250 mL plastic	250 mL	Cool to ≤6°C and adjust to pH <2 with H_2SO_4	28 days

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Water (cont'd)	Total Organic Carbon	Preparation Method: EPA 9060A Preparation SOP: ANA9060 Analysis Method: EPA 9060A Analysis SOP: ANA9060	3 × 40 mL amber VOA vial	5 mL	Cool to ≤6°C and adjust to pH <2 with H_2SO_4	28 days
	Dissolved Organic Carbon	Preparation Method: EPA 9060A Preparation SOP: ANA9060 Analysis Method: EPA 9060A Analysis SOP: ANA9060	3 × 40 mL amber VOA vial	5 mL	Cool to ≤6°C and adjust to pH <2 with H_2SO_4	28 days
	Alkalinity	Preparation Method: SM2320B Preparation SOP: ANA2320B Analysis Method: SM2320B Analysis SOP: ANA2320B	1 × 250 mL plastic	250 mL	Cool to ≤6°C	14 days.
	Total Calcium, Magnesium, Manganese, Potassium, and Sodium	Preparation Method: EPA 3010A Preparation SOP: PRE3010A Analysis Method: EPA 6010C Analysis SOP: ANA6010	1 × 500 mL plastic	500 mL	Adjust to pH <2 with HNO_3 and cool to ≤6°C	6 months.
	Total Silica	Preparation Method: SM4500-SID Preparation SOP: ANA4500SiD Analysis Method: SM4500-SID Analysis SOP: ANA4500SiD	1 × 250 mL plastic	250 mL	Cool to ≤6°C	28 days.
	Dissolved Silica	Preparation Method: SM4500-SID Preparation SOP: ANA4500SiD Analysis Method: SM4500-SID Analysis SOP: ANA4500SiD	1 × 250 mL plastic	250 mL	Field filtered and cool to ≤6°C	28 days.
Sheen Sample/ (Misc.)	Detailed Hydrocarbon Fingerprinting and Evaluation	Preparation SOP: ASTMD3328 Analysis SOP: ASTMD3328	1 × sheen strip sampler in 8-oz glass jar, Teflon-lined closed-top lid (no septum	N/A	none	365 days
LNAPL (If encountered)	Detailed Hydrocarbon Fingerprinting and Evaluation	Preparation SOP: ASTMD3328 Analysis SOP: ASTMD3328	1 × 125 mL glass Teflon-lined closed-top	125 mL	none	No holding Time Requirements for NAPL

g	gram
H_2SO_4	sulfuric acid
HCl	hydrogen chloride
HNO_3	nitric acid
L	liter
LNAPL	light nonaqueous-phase liquid
mL	milliliter
$NaHSO_4$	sodium bisulfate
oz	ounce
PAH	polynuclear aromatic hydrocarbon
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-p-furan
PSD	particle size distribution
SIM	selective ion monitoring
SOP	standard operating procedure
SVOC	semivolatile organic compound
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics
VOA	volatile organic analyte
VOC	volatile organic compound

Worksheet #20: Field Quality Control Sample Summary Table

20.1 SUBSURFACE SOIL SAMPLES

Subsurface Soil Samples		Sample Depth/Location			Analytical Sample Counts						Soil Chemistry & Geotechnical Samples	
Analytical Groups	Sampling Location	At the capillary fringe of each perched and basal aquifer	At the top of each aquitard underlying each perched aquifer [a]	At evidence of observed contamination [b]	Primary Samples [c]	Field Duplicates [d]	MS/ MSDs [e]	Field Blanks [f]	Equipment Blanks [g]	Trip Blanks [h]	Soil Characteristics	Above the capillary fringe
VOCs & TICs TPH-g TPH-d TPH-o SVOCs & TICs PAHs Dioxins/Furans	OWDFMW02A	2	1	—	3	1	1	1	1	3	Atterberg limits Grain size distribution Soil classification Moisture content & density Effective porosity & permeability TOC pH Cation exchange capacity	1
	OWDFMW02B	1	1	1	3	—	—	—	—	3		1
	OWDFMW03A	2	1	—	3	1	1	1	1	3		1
	OWDFMW03B	1	1	1	3	—	—	—	—	3		1
	OWDFMW04A	2	—	1	3	1	1	1	1	3		1
	OWDFMW05A	2	1	—	3	1	1	1	1	3		1
	OWDFMW05B	1	1	1	3	—	—	—	—	3		1
	OWDFMW06A	2	1	—	3	1	1	1	1	3		1
	OWDFMW06B	1	1	1	3	—	—	—	—	3		1
	OWDFMW07A	2	1	—	3	1	1	1	1	3		1
	OWDFMW07B	1	1	1	3	—	—	—	—	3		1
	OWDFMW08A	2	1	—	3	1	1	1	1	3		1
	OWDFMW08B	1	1	1	3	—	—	—	—	3		1
Total Number of Samples					39	7	7	7	7	39	Geotechnical Samples	13

—	not applicable
A	basal aquifer monitoring well
B	perched aquifer monitoring well
bgs	below ground surface
MS	matrix spike
MSD	matrix spike duplicate
MW	monitoring well
OWDF	Oily Waste Disposal Facility
PAH	polynuclear aromatic hydrocarbon
SVOC	semivolatile organic compound
TIC	tentatively identified compound
TOC	total organic carbon
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics
VOC	volatile organic compound

[a] Estimated values based on an average of one perched aquifer per cluster, except at OWDFMW04.
[b] Estimated sample count assuming one per cluster a total of seven samples.
[c] Actual collected count may differ based on field observations.
[d] Duplicate samples based on 10% of analytical samples per sampling event.
[e] MS/MSD extra sample mass will be collected based on 5% of analytical samples per sampling event. Analysis of MS/MSD will follow DOD QSM requirements.
[f] Equipment rinsate blanks based on 5% of analytical samples per sampling event.
[g] One field blank per water source.
[h] One trip blank per analytical method per shipping cooler, actual trip blank analyses may differ from planned.

20.2 GROUNDWATER SAMPLES

		Monitoring Well [a]															Field QC Sample Counts				
Analytical Group	Groundwater Sampling Event	OWDF MW01	OWDF MW02A	OWDF MW02B	OWDF MW03A	OWDF MW03B	OWDF MW04A	OWDF MW04B	OWDF MW05A	OWDF MW06A	OWDF MW06B	OWDF MW07A	OWDF MW07B	OWDF MW08A	OWDF MW08B	Total Primary Samples	Field Duplicates [b]	MS/MSD Pairs [c]	Field Blanks [d]	Equipment Blanks [e]	VOA Trip Blanks [f]
COPC Analysis																					
VOCs & TICs TPH-g TPH-d TPH-o SVOCs & TICs PAHs Dioxins/Furans	1st Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	2	1	1	1	12
	2nd Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	2	1	1	1	12
	3rd Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	2	1	1	1	12
	4th Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	2	1	1	1	12
Total COPC Sample Analyses:																56	8	4	4	4	48
Groundwater Chemistry and Natural Attenuation Parameters																					
Anions Cations Silica Methane Organic Carbon Alkalinity Nitrate-Nitrate Nitrogen Ferrous Iron TPH-d & TPH-o with Silica Gel Cleanup	1st Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	—	—	—	—	—
	2nd Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	—	—	—	—	—
	3rd Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	—	—	—	—	—
	4th Quarterly	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	—	—	—	—	—
Total Groundwater Chemistry Sample Analyses:																56	—	—	—	—	—

A	basal aquifer monitoring well
B	perched aquifer monitoring well
—	not applicable, no sample will be collected
COPC	chemical of potential concern
MS	matrix spike
MSD	matrix spike duplicate
MW	monitoring well
OWDF	Oily Waste Disposal Facility
PAH	polynuclear aromatic hydrocarbon
SVOC	semivolatile organic compound
TIC	tentatively identified compound
TOC	total organic carbon
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics
VOC	volatile organic compound

[a] Duplicate samples based on 10% of analytical samples per sampling event.

[b] MS/MSD samples based on 5% of analytical samples per sampling event.

[c] Equipment rinsate blanks based on 1 per event. Alternatively, they will be collected above 5% of analytical samples per sampling event.

[d] One field blank per water source.

[e] One trip blank per analytical method per shipping cooler; actual trip blank analyses may differ from planned (VOCs, TPH-g, and methane).

[f] Number of samples analyzed for TPH-d and TPH-o with silica gel cleanup will be contingent on positive detections of TPH-d and TPH-o in non-silica-gel-cleaned samples.

Worksheet #21: Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number [a]	Originating Organization of Sampling SOP	Equipment Type	Comments
I-A-6	IDW Management (DON 2015)	NAVFAC Pacific	N/A	No
I-A-8	Sample Naming (DON 2015)	NAVFAC Pacific	N/A	No
I-B-1	Soil Sampling (DON 2015)	NAVFAC Pacific	Split-spoon sampler with liners and core barrel	No
I-B-2	Geophysical Testing Procedure (DON 2015)	NAVFAC Pacific	Low-frequency electromagnetic induction and ground-penetrating radar	No
I-C-1	Monitoring Well Installation and Abandonment (DON 2015)	NAVFAC Pacific	Drill rig	No
I-C-2	Monitoring Well Development (DON 2015)	NAVFAC Pacific	Surge block or submersible pump	No
I-C-3	Monitoring Well Sampling (DON 2015)	NAVFAC Pacific	Bladder pump	No
I-D-1	Drum Sampling (DON 2015)	NAVFAC Pacific	COLIWASA or glass thieving tubes	No
I-E	Soil and Rock Classification (DON 2015)	NAVFAC Pacific	N/A	No
I-F	Equipment Decontamination (DON 2015)	NAVFAC Pacific	N/A	No
I-I	Land Surveying (DON 2015)	NAVFAC Pacific	GPS	No
III-A	Laboratory QC Samples (Water, Soil) (DON 2015)	NAVFAC Pacific	N/A	No
III-B	Field QC Samples (Water, Soil) (DON 2015)	NAVFAC Pacific	N/A	No
III-D	Logbooks (DON 2015)	NAVFAC Pacific	N/A	No
III-E	Record Keeping, Sample Labeling, and Chain of Custody Procedures (DON 2015)	NAVFAC Pacific	N/A	No
III-F	Sample Handling, Storage and Shipping (DON 2015)	NAVFAC Pacific	N/A	No

COLIWASA	composite liquid waste sampler
GPS	global positioning system
IDW	investigation-derived waste
N/A	not applicable
NAVFAC	Naval Facilities Engineering Systems Command
QC	quality control
SOP	standard operating procedure

[a] Applicable procedures from the *Project Procedures Manual* (DON 2015).

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

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
PID Meter	Calibrate with ambient air and a calibration span gas (100 ppm isobutylene).	Keep batteries charged.	Calibrate with calibration gas.	Visually inspect meter for wear or damage before calibration.	Daily	Stable and acceptable readings achieved per manufacturer's instructions	If readings do not stabilize, do not use device.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Water Quality Parameter Probe [b]	Calibrate with calibration solutions (pH buffers and conductivity and turbidity solutions).	Decontaminate after every use. Keep batteries charged.	Calibrate with calibration solutions.	Visually inspect probes for wear or damage. Run a calibration.	Daily	Stable readings achieved (three or more successive readings within 10% of each other)	If readings do not stabilize, do not use device.	Field Manager	Procedure I-C-3: Monitoring Well Sampling (DON 2015) and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Bladder or submersible pumps	N/A.	Decontaminate pumps between wells and dispose of tubing.	Determine if pumps are working correctly. Adjust flow rate (purge rate) to yield 100–300 mL/minute. Operate at low flow for several minutes.	Visually inspect for damage.	Daily	Pump is not creating significant draw-down (i.e., ≤0.2 foot)	Reduce pumping rate and continue to monitor draw-down with water level meter until acceptance criterion is met.	Field Manager	Procedure I-C-3: Monitoring Well Sampling (DON 2015) and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Dust Monitor	Calibrate per manufacturer's instructions.	Keep batteries charged.	Activities per manufacturer's instructions.	Visually inspect meter for wear or damage before calibration.	Daily	Stable and acceptable readings achieved per manufacturer's instructions	If readings do not stabilize, do not use device.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Noise Dosimeter	Prior to work on the project site, calibrate against QC-10 calibrator.	Visual inspection.	Check daily and calibrate against QC-10 calibrator.	Visually inspect for wear of damage and daily check.	Every 8 hours	70–143 dB	Return to manufacturer for recalibration.	Field Manager	No SOP. Maintenance and inspection in accordance with manufacturer's recommendation.

%	percent
dB	decibel
dGPS	dead reckoning Global Positioning System
mL	milliliter
N/A	not applicable
PID	photoionization detector
ppm	parts per million
SOP	standard operating procedure

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

[b] Used for monitoring temperature, pH, specific conductivity, turbidity, and dissolved oxygen.

Worksheet #23: Analytical SOP References Table

Laboratory: APPL, 908 North Temperance Avenue, Clovis, CA 96311
Laboratory Project Point of Contact: Libby Cheeseborough, 559-275-2175, libby@applinc.com

Laboratory SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
Misc., Preparatory and Analytical Methods						
QC018	Method Detection Limit Studies, Limit of Detection and Limit of Quantitation REV.36, 09/02/2019	Definitive	All (Soil and Groundwater)	GC-ECD/GC-FID/ GC-MS	No	No
SON001	TPH-d and TPH-o Sonication Extraction of Soil, Sludge and Solid (EPA Method 3550C) Revision: 06, 04/14/2020	Definitive	TPH–d/o (Soil)	Preparation	No	No
SON001	8270 and PAH Sonication Extraction of Soil, Sludge and Solids (EPA Method 3550C) Revision: 06, 04/14/2020	Definitive	PAHs, SVOCs (Soil)	Preparation	No	No
HPL8280	PCDDs and PCDFs (EPA Method 8290) Soxhlet Extraction of Soil/Sediment Revision: 14, 06/26/2019	Definitive	Dioxins (Soil and Water)	Preparation	No	No
LQ001	Continuous Liquid-Liquid Extraction EPA 3520C, Rev 6, 12/20/2017	Definitive	PAHs, TPH-d/o (Water)	Preparation	No	No
SEP011	Total Hydrocarbon (THC) Separatory Funnel Extraction of Water (EPA Method 3510C) Revision: 08, 04/30/2020	Definitive	TPH–d/o (Water)	Preparation	No	No
SEP004	625/8270 Separatory Funnel Extraction of Water (EPA Method 3510C) Revision: 04, 01/10/2020	Definitive	SVOCs and PAHs (Water)	Preparation	No	No
CLN004	Silica Gel Cleanup Procedure for Total Petroleum Hydrocarbon Extracts EPA Method 3630C, Rev 3, 04/04/2018	Definitive	TPH-d/o Silica Gel Cleanup (Water)	Preparation	No	No
PREP3010A	Acid Digestion of Aqueous Samples and Extracts for Total and Dissolved Metals for Analysis by ICP Spectroscopy or ICP Mass Spectroscopy (EPA Method 3010A) Revision: 03, 06/05/2020	Definitive	Metals/Cations (Water)	Preparation	No	No
ANA 8260	Closed-System Purge-and-Trap (EPA Method 5035A) Revision: 27, 03/22/2020	Definitive	VOCs and TPH-g (Soil and Water)	Preparation	No	No
ANA 9081	Cation-Exchange Capacity of Soils (sodium acetate) Revision: 01, 10/15/2019	Definitive	CEC (Soil)	Preparation	No	No
ANA9040C	pH (EPA Method 9040C) Revision: 03,11/19/2019	Definitive	pH	Metrohm Tiamo	No	No
ANAISM02-2	Percent Solids and Percent Moisture Analysis of Solids (EPA 8000C) Revision: 05, 0722/2019	Definitive	Percent Moisture (Soil)	N/A	No	No

Laboratory SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
ANA 8260	Analysis of Water/Soil/Sludge(EPA Method 8260C) Revision: 27, 03/22/2020	Definitive	VOCs (Soil and Water)	GC-MS	No	No
ANA 8260	TPH (EPA Method 8260C) Revision: 27, 03/22/2020	Definitive	TPH-g (Soil and Water)	GC-MS	No	No
ANA 8015	Determination of TPH in Water, Sludges and Soils by GC-FID Revision: 12, 06/10/2020	Definitive	TPH –d/o (Soil and Water)	GC-FID	No	No
ANA 8270	SVOCs (EPA Method 8270D) Revision: 14, 02/15/2020	Definitive	SVOCs (Soil and Water)	GC-MS	No	No
ANA 8270SIM	PAHs by Selective Ion Monitoring Modified (EPA Method 8270D) Revision: 10, 10/28/2019	Definitive	PAHs (Soil and Water)	GC-MS	No	No
HPL8290	Instrumental analysis of PCDD and PCDF by HRGC-HRMS (EPA Method 8290) Revision: 14, 06/26/2019	Definitive	Dioxins (Soil and Water)	GC-HRMS	No	No
Soil and Groundwater Chemistries						
ANA RSK175	Dissolved Gas Analysis in Water by Headspace Gas Chromatography Revision: 10, 10/28/2019	Definitive	Methane (Water)	GC-FID	No	No
ANA 3500FeBc	Ferrous & Ferric Iron Analysis, Standard Methods SM3500-FeBc Revision: 05, 11/16/2019	Definitive	Ferrous Iron (Water)	Spectrophotometer	No	No
ANA 353-2	Total Oxidizable Nitrogen, Nitrate, and Nitrite Analysis (EPA Method 353.2) Revision: 11, 08/24/2019	Definitive	Nitrate-Nitrite as Nitrogen	Automated Ion Analyzer	No	No
HPL9056	Inorganic Ion Analysis by EPA Method 9056A Revision: 15, 0507/2020	Definitive	Nitrate, Sulfate, Chloride, Bromide, Fluoride (Water)	Ion chromatograph	No	No
ANA 2320B	Total Alkalinity, EPA 310.1 and Standard Method 2320B Revision: 05, 03/05/2020	Definitive	Alkalinity (Water)	Ion chromatograph	No	No
ANA 9081	Cation-Exchange Capacity of Soils (sodium acetate) (EPA Method 9081) Revision: 01, 10/15/2019	Definitive	CEC (Soil)	N/A	No	No
ANAWalkleyBlk	Total Organic Carbon (Walkley-Black Method for Soils) Revision: 04, 04/07/2020	Definitive	Total Organic Carbon (Soil)	Total Organic Carbon Analyzer	No	No

Laboratory SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
ANA 9060A	Total Organic Carbon (EPA Method 9060A) Revision: 13, 05/20/2020	Definitive	Total and Dissolved Organic Carbon (Water)	Total Organic Carbon Analyzer	No	No
ANA 6010	Inductively Coupled Plasma-Atomic Emission Spectroscopy (EPA Method 6010) Revision: 14, 06/08/2020	Definitive	Total Calcium, Magnesium, Manganese, Potassium, and Sodium (Water)	ICP-AES	No	No
ANAN 4500 SiD	Dissolved Silica Analysis, Standard methods 4500SiD Revision: 03, 04/15/2020	Definitive	Total and Dissolved Silica (Water)	Ion chromatograph	No	No

Note: The laboratory SOPs listed in Worksheet #23 are the most current revisions at the time of publication of this WP. AECOM will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the DoD QSM annual review requirement.

ASTM	ASTM International
BNA	base neutrals and acids
BRL	Brooks Rand Laboratory
CARB	carbamate
CEC	cation exchange capacity
CLP	Contract Laboratory Program
CVAA	cold vapor atomic absorption
DoD	Department of Defense
DRO	diesel range organics
EPA	Environmental Protection Agency, United States
GC-ECD	gas chromatography–electron capture detection
GC-FID	gas chromatography-flame ionization detector
GC-HRMS	gas chromatograph–high-resolution mass spectrometry
GC-MS	gas chromatography–mass spectrometry
GRO	gasoline range organics
HPLC-UV	high-performance liquid chromatography–ultraviolet detector
HRGC	high-resolution gas chromatography
HRMS	high-resolution mass spectrometry
ICP-AES	inductively coupled plasma–atomic emission spectroscopy
LRO	lube oil range organics
N/A	not applicable
no.	number
NOAA	National Oceanic and Atmospheric Administration
PAH	polynuclear aromatic hydrocarbon
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-p-furan
PSD	particle size distribution
QSM	Quality Systems Manual
SIM	selective ion monitoring
SOP	standard operating procedure
SVOC	semivolatile organic compound
THC	total hydrocarbons
TOC	total organic carbon
TPH	total petroleum hydrocarbons
VOC	volatile organic compound

Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260C, 8270D, 8720D SIM	Tuning	Prior to ICAL and at the beginning of each 12-hour period	Refer to method for specific ion criteria.	Retune instrument and verify. Rerun affected samples.	Laboratory Manager/ Analyst or certified instrument technician	ANA 8260 ANA 8270 ANA 8270SIM
	Breakdown check (DDT-Method 8270 only)	At the beginning of each 12-hour period, prior to analysis of samples	Degradation ≤20% for DDT. Benzidine and pentachlorophenol should be present at their normal responses, and should not exceed a tailing factor of 2.	Correct problem, then repeat breakdown checks.	Laboratory Manager/ Analyst or certified instrument technician	
	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic calibration	Prior to sample analysis	RSD for each analyte ≤15% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995.	Correct problem, then repeat ICAL.	Laboratory Manager/ Analyst or certified instrument technician	
	Second source calibration verification	After ICAL	All analytes within ±20% of expected value.	Correct problem and verify second source standard; rerun second source verification. If fails, correct problem and repeat initial calibration.	Laboratory Manager/ Analyst or certified instrument technician	
	RT window position for each analyte and surrogate	Once per ICAL	Position will be set using the midpoint standard for the ICAL.	N/A.	Laboratory Manager/ Analyst or certified instrument technician	
	RRT	With each sample	RRT of each target analyte in each calibration standard within ±0.06 RRT units of ICAL.	Correct problem, then reanalyze all samples analyzed since the last RT check. If fails, then rerun ICAL and samples.	Laboratory Manager/ Analyst or certified instrument technician	
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence	All analytes within ±20% of expected value (%D). All reported analytes and surrogates within ± 50% for end of analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Laboratory Manager/ Analyst or certified instrument technician	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260C, 8270D, 8720D SIM (cont'd)	IS	Each CCV and sample	RT ± 10 seconds from RT of the ICAL mid-point standard. EICP area within -50% to +100% of area from IS in ICAL mid-point standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed during failure is mandatory.	Laboratory Manager/ Analyst or certified instrument technician	ANA 8260 ANA 8270 ANA 8270SIM
GC-FID EPA Method 8015B	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic calibration	Prior to sample analysis	RSD for each analyte ≤20% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995.	Correct problem, then repeat initial calibration.	Laboratory Manager/ Analyst or certified instrument technician	ANA8015
	Second source calibration verification	Once after each initial calibration	Analytes within ±20% of expected value (initial source), and within established RT windows.	Correct problem and verify second source standard. Rerun second source verification. If fails, correct problem and repeat initial calibration.	Laboratory Manager/ Analyst or certified instrument technician	
	RT window width	At method set-up and after major maintenance	RT width is ± 3 times standard deviation for each analyte RT from 72-hour study. For TPH-d: calculate RT based on C12 and C25 alkanes.	N/A.	Laboratory Manager/ Analyst or certified instrument technician	
	Establishment and verification of the RT window for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift for establishment of RT; and with each CCV for verification of RT	Using the midpoint standard or the CCV at the beginning of the analytical shift for RT establishment; and analyte must fall within established window during RT verification.	N/A.	Laboratory Manager/ Analyst or certified instrument technician	
	Run second source calibration verification (ICV)	ICV: Daily, before sample analysis, unless ICAL performed same day	All analytes within ±20% of expected value (%D).	Correct problem and rerun ICV. If fails, repeat initial calibration.	Laboratory Manager/ Analyst or certified instrument technician	
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence	All analytes within ±20% of expected value (%D).	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Laboratory Manager/ Analyst or certified instrument technician	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
HRGC/HRMS EPA Method, 8290A	MDL study	At initial set-up and subsequently once per 12-month period; otherwise quarterly MDL verification checks	See 40 CFR 136B. MDL verification checks must produce a signal at least 3 times the instrument's noise level.	Run MDL verification check at higher level and set MDL higher or reconduct MDL study.	Laboratory Manager/ Analyst or certified instrument technician	HPL8290
	Mass tuning using PFK	Prior to ICAL or CCV and after every 12-hour period	Static resolving power ≥10,000 (10% valley) for identified masses and lock-mass ion between lowest and highest masses for each descriptor and level of reference compound ≤10% full-scale deflection.	Retune instrument; verify. Rerun affected samples.	Laboratory Manager/ Analyst or certified instrument technician	
	GC column performance check – WDM	Prior to ICAL or CCV and after every 12-hour period	Identification of all of first (F) and last (L) eluters of eight homologue RT windows by labeling (F/L) on the chromatogram, and absolute retention times for switching from one homologous series to the next ≥10 seconds for all components of the mixture.	Correct problem, then repeat column performance check.	Laboratory Manager/ Analyst or certified instrument technician	
	GC column performance check (Method 8290 only)	Prior to ICAL or CCV	Using selected ion current profiles for each isomer, peak separation between 2,3,7,8-TCDD and other TCDD isomers valley of ≤25%.	Correct problem, then repeat column performance check.	Laboratory Manager/ Analyst or certified instrument technician	
	ICAL – minimum of 5 standards for all target analytes	Prior to sample analysis, as needed by failure of routine CCV or when new lot is used for standard source of CCV, sample fortification (internal standards), or recovery standards	Ion abundance ratios in accordance with each method, and signal-to-noise ratio ≥0 for all target analyte ion current profiles, and RSD ≤20% for the RF for all 17 unlabeled standards, and RSD ≤20% for the RFs for the 9 labeled internal standards.	Correct problem, then repeat ICAL.	Laboratory Manager/ Analyst or certified instrument technician	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
HRGC/HRMS EPA Method 8290A (cont'd)	CCV	Before sample analysis of each 12-hour period, and at the end of the analysis sequence	Ion abundance ratios in accordance with each method, and RF within ±20% D (difference) for unlabeled standards from mean RF from ICAL, and RF within ±30% D for labeled standards from mean RF from ICAL.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. End-of-run CCV: If the RF for unlabeled standards ≤25% RPD and the RF for labeled standards ≤5% RPD (relative to the RF established in the ICAL), the mean RF from the two daily CCVs must be used for quantitation of impacted samples instead of the ICAL mean RF value. If the starting and ending CCV RFs differ by more than 25% RPD for unlabeled compounds and 35% RPD for labeled compounds, the sample may be quantified against a new calibration if it is analyzed within 2 hours. Otherwise reanalyze samples with positive detections if necessary.	Laboratory Manager/ Analyst or certified instrument technician	HPL8290
	PCDD/PCDF identification (Method 8290 only)	Verify all sample positive detections	2,3,7,8-substituted isomers with labeled standards: Absolute RT at maximum height within -1 to +3 seconds of that for corresponding labeled standard; 2,3,7,8-substituted isomers with unlabeled standards: RRT within 0.005 RRT units of that in calibration verification standard; Non-2,3,7,8-substituted isomers: RT within RT window established by column performance check solution for corresponding homologue, per method; and ions for quantitation must maximize simultaneously (± 2 seconds); and Ion abundance ratios in accordance with criteria in Table 8 of the method; and S/N ratio of ISs ≥10 times background noise; and S/N ratio of all remaining ions for unlabeled analytes ≥2.5 times background noise; and For PCDF: No signal present having a S/N ratio ≥2.5 for the corresponding ether (PCDPE) detected at the same retention time (±2 sec).	Correct problem, then re-prep and reanalyze the sample(s) with failed criteria for any of the internal, recovery, or cleanup standards. If PCDPE is detected or if sample peaks present do not meet ion abundance ratio criteria, calculate the EMPC.	Laboratory Manager/ Analyst or certified instrument technician	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
Carbonaceous Analyzer-TOC (Walkley-Black Method)	Initial Calibration (ICAL) for all analytes (Minimum 5 standards and a calibration blank.)	ICAL prior to sample analysis	r ≥ 0.995.	Correct problem, then repeat ICAL.	Laboratory Manager/ Analyst	ANAWalkleyBlk
	Second-source calibration verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	Reported analyte within ± 10% of true value.	Correct problem and rerun ICV. If that fails, correct problem and prepare new curve and new ICV.	Laboratory Manager/ Analyst	
	Continuing calibration verification (CCV)	Before sample analysis; after every 10 field samples; and at the end of the analysis sequence.	Reported analyte within ± 10% of true value.	Correct problem, then rerun CCV. If that fails, correct problem and prepare new curve and new CCV. then reanalyze all affected samples since the last acceptable CCV.	Laboratory Manager/ Analyst	
ICP-AES EPA Method 6010C	Establish IDLs	Every 3 months	In accordance with manufacturer's recommendation or Laboratory SOP.	Notify the manufacturer if problem occurs.	Certified instrument technician	ANA 6010
	Calibrate using the multi-point standard calibration	Daily prior to analysis of sample	Correlation coefficient ≥0.995.	Correct problem, then repeat initial calibration.	Laboratory Manager/ Analyst or certified instrument technician	
	Establish linear dynamic range	Once every 6 months or when the system is repaired	The calculated value should be within ± 10% of the true value.	Correct problem, then repeat the calibration process.	Laboratory Manager/ Analyst or certified instrument technician	
	Run interference check solution (ICS)	At the beginning of analytical run	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.	Correct problem, then repeat the calibration process or use internal standards to eliminate the problem.	Laboratory Manager/ Analyst or certified instrument technician	
	Run second source calibration verification (ICV)	Once after standard calibration	All reported analytes within ±10% of its true value.	Correct problem, then repeat the calibration process.	Laboratory Manager/ Analyst or certified instrument technician	
	Run CCV	Once every 10 samples	All reported analytes within ±10% of its true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Laboratory Manager/ Analyst or certified instrument technician	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
ICP-AES EPA Method 6010C (cont'd)	Run CCB	Once every 10 samples	No analytes detected >LOD.	Terminate analysis; recalibrate and reanalyze the samples.	Laboratory Manager/ Analyst or certified instrument technician	ANA6010
Spectrophotometer	ICAL (minimum three standards and a calibration blank)	Daily ICAL prior to sample analysis	r ≥ 0.995.	Correct problem, then repeat ICAL.	Laboratory Manager/ Analyst	ANA 3500FeBc ANA353.2
	Second-source calibration verification (ICV)	Before beginning a sample run	Value of second source within ± 10% of true value.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat calibration.	Laboratory Manager/ Analyst	
Ion Chromatograph	Initial Calibration (ICAL) for all analytes (Minimum 3 standards and a calibration blank.)	Daily ICAL prior to sample analysis	r ≥ 0.99.	Correct problem, then repeat ICAL.	Laboratory Manager/ Analyst	HPL9056, ANA2320B ANA 4500SiD
	Second-source calibration verification (ICV)	Once after each ICAL, analysis of a second source standard prior to sample analysis.	All reported analytes within established RT windows. All reported analytes within ± 10% of true value.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat calibration.	Laboratory Manager/ Analyst	
	Continuing calibration verification (CCV)	Before sample analysis; after every 10 field samples; and at the end of the analysis sequence	All reported analytes within established retention time windows. All reported analytes within ± 10% of true value.	Recalibrate, and reanalyze all affected samples since the last acceptable CCV; or Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Laboratory Manager/ Analyst	
Water Bath	Measure water temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Laboratory Manager/ Analyst or certified instrument technician	Manufacturer Manual

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
Drying Oven	Measure oven temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer’s recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Laboratory Manager/ Analyst or certified instrument technician	Manufacturer’s Manual
Analytical Balance	Calibrate against verified (National Institute of Standards and Technology) mass	Daily or prior to analyzing samples	In accordance with unit model and manufacturer’s recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Laboratory Manager/ Analyst or certified instrument technician	
pH Meter	Run a minimum 3-point calibration; run CCV	Daily or prior to analyzing samples; one CCV for every 10 samples	±0.05 unit.	Terminate analysis, recalibrate, and verify before sample analysis.	Laboratory Manager/ Analyst or certified instrument technician	

%	percent
%D	percent difference
amu	atomic mass unit
CA	corrective action
CCB	continued calibration blank
CCV	continued calibration verification
CFR	Code of Federal Regulations
CRDL	contract-required detection limit
CVAA	cold vapor atomic absorption
D	difference
DRO	diesel range organics
EICP	extracted ion current profile
EMPC	estimated maximum possible concentration
EPA	Environmental Protection Agency, United States
GC-ECD	gas chromatography–electron capture detection
GC-FID	gas chromatography–flame ionization detector
GC-MS	gas chromatography–mass spectrometry
HPLC	high-performance liquid chromatography
HRGC	high-resolution gas chromatography
HRMS	high-resolution mass spectrometry
IC	initial calibration
ICAL	initial calibration
ICP-AES	inductively coupled plasma–atomic emission spectroscopy
ICP-MS	inductively coupled plasma–mass spectroscopy
ICS	interference check solution
ICV	initial calibration verification
IDL	instrument detection limit
IS	internal standard
LOD	limit of detection
LOQ	limit of quantitation
MDL	method detection limit
m/z	mass-to-charge ration
N/A	not applicable
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-p-furan
PCDPE	polychlorinated diphenyl ether
PFK	perfluorokerosene
RF	response factor
RRT	relative retention time
RSD	relative standard deviation
RT	retention time
S/N	signal-to-noise ratio
SIM	selective ion monitoring
SOP	standard operating procedure
TCDD	tetrachlorodibenzo-p-dioxin
TOC	total organic carbon
TPH	total petroleum hydrocarbons

[a] Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet #23).

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

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-FID and GC-MS	Change gas purifier.	N/A.	Visually inspect if traps are changing color.	Every 6–12 months	No moisture.	Replace indicating traps.	Analyst or certified instrument technician	ANA 8015 ANA8260 ANA8270 ANARSK175
	Change syringes/ syringe needles.	N/A.	Visually inspect for wear or damage.	Every 3 months	N/A.	Replace syringe if dirt is noticeable in the syringe.	Analyst or certified instrument technician	
	Change inlet liner, liner O-rings, and inlet septum.	N/A.	Visually inspect for dirt or deterioration.	Weekly for liner Monthly for O-rings Daily for septum	N/A.	Replace and check often.	Analyst or certified instrument technician	
	Change front-end column.	N/A.	Check peak tailing, decreased sensitivity, retention time changes, etc.	Weekly, monthly, or when needed	N/A.	Remove 1/2 to 1 meter from the front of the column when experiencing problems.	Analyst or certified instrument technician	
GC-FID	Clean injector ports.	N/A.	N/A.	As needed	N/A.	N/A.	Analyst	ANA8015 ANARSK175
	Replace trap on purge-and-trap systems.	N/A.	N/A.	Bi-monthly or as needed	N/A.	N/A.	Analyst	
	Replace detector jets.	N/A.	N/A.	As needed	N/A.	N/A.	Analyst	
	Replace hydrocarbon traps and oxygen traps on helium and hydrogen gas lines.	N/A.	N/A.	Every 4-6 months	N/A.	N/A	Analyst	
	Replace chemical trap.	N/A.	N/A.	Yearly or as needed	N/A.	N/A.	Analyst	
	Replace converter tube in gas purifier system.	N/A.	N/A.	Yearly or as needed	N/A.	N/A.	Analyst	

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-MS, HRGC-HRMS	Change tune MSD, check the calibration vial, and replace the foreline pump oil.	N/A.	Visually inspect and monitor the fluid becoming discolored.	As needed or every 6 months	In accordance with manufacturer's recommendation or laboratory SOP.	Keep plenty of PFTBA; refill the vial and check the fluid; change when the fluid becomes discolored.	Analyst or certified instrument technician	ANA8260 ANA8270 HPL8290
	Run tuning program to determine if source is functioning properly.	N/A.	N/A.	Daily	N/A.	Cool system, vent, disassemble and clean.	Analyst	
	N/A.	Tune instrument.	N/A.	Daily or every 12 hours	Per method.	Liner and septa are replaced; tune file used is manually adjusted.	Analyst	
	Replace columns.	N/A.	N/A.	If chromatograms indicate possible contamination	N/A.	N/A.	Analyst	
	Vacuum rough pump oil level is checked.	N/A.	N/A.	Every 4-6 weeks	N/A.	Add oil if needed.	Analyst	
	Replace/refill carrier gas line oxygen and moisture traps.	N/A.	N/A.	Yearly or as needed	N/A.	N/A.	Analyst	
ICP-AES	Check instrument connections, gas flow, and pressure.	Conduct leak test.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Intensity of spectrum is within manufacturer's recommendation.	Call for maintenance service.	Analyst or certified instrument technician	ANA6010
	Clean the torch in Aqua Regia solution and align the torch.	Conduct leak test and adjust alignment.	Inspect for leaks and align the torch and ensure that it is in the center.	Each week (minimum every 2 weeks)	Torch is centered and no leaks.	Replace or call for maintenance service.	Analyst or certified instrument technician	
	Clean the chamber and nebulizer.	N/A.	Visually inspect for foreign objects.	Each week	Make sure chamber and nebulizer are clean.	Replace or call for maintenance service.	Analyst or certified instrument technician	
	Clean the lens and optimize the detector sensitivity.	N/A.	Clean up the dust from the lens.	Every 6 months	In accordance with manufacturer's recommendation or laboratory SOP.	Install new lens.	Certified instrument technician	

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
Spectrophoto-meter	Rinse cartridges.	N/A.	Check for wear, cracks, and acid damages	Daily	N/A.	N/A.	Analyst or certified instrument technician	ANA353.2 ANA 3500FeBC
	Clean pump rollers, remove rust, and apply silicon spray. Replace O-rings, clean valve ports, replace stained tubing.	N/A.	N/A	Monthly	N/A.	N/A.	Analyst or certified instrument technician	
Ion Chromatograph	Inject DI rinse at the end of every run; rinse the piston seals.	N/A.	Check for and isolate leaks	Daily	None.	Clean up and repair any leaks.	Analyst or certified instrument technician	HPL9056 ANA2320B ANA4500SiD
	Locate and replace any pinched or damaged airlines.	N/A.	N/A	Weekly	N/A.	N/A.	Analyst or certified instrument technician	
	Replace primary and rinse seals in pump heads.	N/A.	N/A	Every 6 months, more frequently if needed	N/A.	N/A.	Analyst or certified instrument technician	
Carbonaceous Analyzer-TOC	Clean the instrument; Check instrument connections and change gas; dispose of wastes.	Monitor temperature and detector sensitivity.	Visually inspect for wear of damage and check indicators from computer controls.	Daily or when needed	Refer to manufacturer's recommendation.	Call for maintenance service.	Analyst or certified instrument technician	ANA9060A ANAWalkleyBlk
Water Bath (Precision Microprocessor controlled)	Check instrument connections, water level, and thermometer.	Measure water temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation.	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	Manufacturer's Manual
Drying Oven	Thermometer indicator.	Measure oven temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation.	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	Manufacturer's Manual

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
Analytical Balance	Check digital LCD display and ensure a flat base for the Instrument.	Calibrate against verified (NIST) mass.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation.	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	Manufacturer's Manual
pH meter	Check LCD display and pH probe.	3 point calibration using known standards.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	± 0.05 unit.	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified manufacture instrument technician	Manufacturer's Manual

GC-ECD	gas chromatography–electron capture detection
GC-FID	gas chromatography–flame ionization detector
GC-MS	gas chromatography–mass spectrometry
HPLC	high-performance liquid chromatography
HRGC	high-resolution gas chromatography
HRMS	high-resolution mass spectrometry
ICP-AES	inductively coupled plasma–atomic emission spectroscopy
ICP-MS	inductively coupled plasma–mass spectrometry
LCD	liquid crystal display
MSD	matrix spike duplicate
N/A	not applicable
NIST	National Institute of Standards and Technology
PFTBA	perfluorotributylamine
SOP	standard operating procedure
TOC	total organic carbon
UV	ultraviolet

[a] Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet #23).

Worksheet #26: Sample Handling System

Item	Personnel/Organization/Time Limit
Sample Collection, Packaging, and Shipment	
Sample Collection	Field manager, field QC coordinator, field geologist/AECOM
Sample Packaging	Field manager, field QC coordinator, field geologist/AECOM
Coordination of Shipment	Field QC coordinator, field geologist/AECOM
Type of Shipment/Carrier	Insulated cooler/FedEx Corporation
Sample Receipt and Analysis	
Sample Receipt	Sample custodian/APPL
Sample Custody and Storage	Sample custodian/APPL
Sample Preparation	Laboratory analyst/APPL
Sample Determinative Analysis	Laboratory analyst/APPL
Sample Archiving	
Field Sample Storage	90 days from sample receipt
Sample Extract/Digestate Storage	90 days from extraction/digestion
Biological Sample Storage	Not applicable or per project scope
Sample Disposal	
Personnel/Organization	Sample custodian/APPL
Number of Days from Analysis	90 days

AECOM	AECOM Technical Services, Inc.
APPL	Agriculture & Priority Pollutants Laboratories, Inc.
no.	number
QC	quality control

Worksheet #27: Sample Custody Requirements

Each sample will be assigned a chain-of-custody (COC) sample identification (ID) number and a descriptive ID number in accordance with NAVFAC Pacific Environmental Restoration Program Procedure I-A-8, *Sample Naming* (DON 2015). All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). The COC sample ID number (the only ID number submitted to the analytical laboratory) is used to facilitate data tracking and storage. The COC sample ID number allows all samples to be submitted to the laboratory without providing information on the sample type or source. The descriptive ID number is linked to the COC sample ID number, which provides information regarding sample type, origin, and source.

27.1 COC SAMPLE IDENTIFICATION NUMBER

A COC sample ID number will be assigned to each sample as follows, to facilitate data tracking and storage:

HUzzz

Where:

H = Designating the sampling team's home office (e.g., Honolulu office)
U = Designating CTO 0063
zzz = Chronological number, starting with 001

Quality control (QC) samples will be included in the chronological sequence.

27.2 DESCRIPTIVE IDENTIFICATION NUMBER

A descriptive ID number (for internal use only) will identify the sampling location, type, sequence, matrix, and depth. The descriptive ID number is used to provide sample-specific information (e.g., location, sequence, and matrix). The descriptive identifier is not revealed to the analytical laboratory. The descriptive ID number for all samples is assigned as follows:

AAA-bbcc-dee-Dff.f

Where:

AAA = Site area (Table 27-1)
bb = Sample type and matrix (Table 27-2)
cc = Location number (e.g., Borehole 01, 02, 03)
d = Field QC sample type (Table 27-3)
ee = Chronological sample number from a particular sampling location (e.g., 01, 02)
D = The letter "D" denoting depth
ff.f = Depth of sample in feet below ground surface (bgs) (measured to the tenth of a foot). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

For example, the sample number OWDFMW03B-BS01-S01-D30.0 would indicate that the sample is the primary sample collected from subsurface soil, encountered at 30 feet bgs, from the borehole advanced for the perched well at monitoring well cluster OWDFMW03. The duplicate sample would be designated as OWDFMW03B-BS01-D01-D30.0. These characters will establish a unique descriptive identifier that will be used during data evaluation.

Table 27-1: Area Identifiers

Identifier	Site Area
OWDFMW01	Existing Monitoring Well OWDFMW01
OWDFMW02A	Proposed Cluster OWDFMW02—Basal Aquifer Well
OWDFMW02B	Proposed Cluster OWDFMW02—Perched Aquifer Well
OWDFMW03A	Proposed Cluster OWDFMW03—Basal Aquifer Well
OWDFMW03B	Proposed Cluster OWDFMW03—Perched Aquifer Well
OWDFMW04A	Proposed Cluster OWDFMW04—Basal Aquifer Well
OWDFMW05A	Proposed Cluster OWDFMW05—Basal Aquifer Well
OWDFMW05B	Proposed Cluster OWDFMW05—Perched Aquifer Well
OWDFMW06A	Proposed Cluster OWDFMW06—Basal Aquifer Well
OWDFMW06B	Proposed Cluster OWDFMW06—Perched Aquifer Well
OWDFMW07A	Proposed Cluster OWDFMW07—Basal Aquifer Well
OWDFMW07B	Proposed Cluster OWDFMW07—Perched Aquifer Well
OWDFMW08A	Proposed Cluster OWDFMW08—Basal Aquifer Well
OWDFMW08B	Proposed Cluster OWDFMW08—Perched Aquifer Well

Table 27-2: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
BS	Subsurface Soil	Soil
BG	Subsurface (Geotechnical)	Solid
GW	Groundwater	Water
FP	Free Product	LNAPL
SH	Sheen Sample	Miscellaneous Solid
WQ	Water Blanks	Water
PW	Potable Water	Water
WS	Waste (IDW)	Soil
WW	Waste (IDW)	Water

Table 27-3: Field QC Sample Type Identifiers

Identifier	Field or QC Sample Type	Description
A	Ambient Blank	Water
S	Primary Sample	All field samples, except QC samples
D	Duplicate	Co-located for soil (adjacent liners)/replicate for water
E	Equipment Blank	Water
B	Field Blank	Water
T	Trip Blank	Water

27.3 HANDLING, SHIPPING, AND CUSTODY

All samples collected for analysis will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). All samples will be labeled and recorded on COC forms in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures* (DON 2015). Samples will be handled, stored, and shipped in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015). All samples collected on this project will be shipped to the analytical laboratory via overnight airfreight.

All samples received at the analytical laboratory will be managed in accordance with laboratory SOPs for receiving samples, archiving data, and sample disposal and waste collection, as well as, storage and disposal per Section 5.8, "Handling Samples and Test Items" of the *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, Version 5.3 (DoD and DOE 2019).

Worksheet #28: Laboratory QC Samples Table

Matrix	**Subsurface Soil & Groundwater**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260C Laboratory SOPs: ANA8260
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Laboratory QC018 and ANA8260.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Laboratory SOP ANA8260 and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Tune Check	Prior to the initial calibration and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.

Matrix	**Subsurface Soil & Groundwater**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260C Laboratory SOPs: ANA8260
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value. All reported analytes and surrogates within ± 50% for the end of the analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. If the specific version of a method requires additional evaluation (e.g., average response factors) these additional requirements must also be met.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and ANA8260.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. Results may not be reported without a valid LCS.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and ANA8260. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019) for LCS.
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ± 10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.

Matrix	**Subsurface Soil & Groundwater**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260C Laboratory SOPs: ANA8260
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Surrogate spike	All field and QC samples.	Per DoD QSM 5.3 (DoD and DOE 2019), Method SW-846 8260C and ANA8260.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Trip blank	One per cooler.	Target analytes ≤1/2 LOQ.	Reanalyze for confirmation through a second analysis of the trip blank. Examine the PQOs.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Bias/ Representativeness/ Contamination	Target analytes ≤1/2 LOQ.

%	percent
BFB	4-bromofluorobenzene
CCV	continuing calibration verification
DFTPP	decafluorotriphenylphosphine
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
VOC	volatile organic compound

Matrix	**Soil and Water**
Analytical Group	**TPH-g**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8260B Laboratory SOPs: ANA8260
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Laboratory QC018 & ANA8260.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by ANA8260 at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.

Matrix	**Soil and Water**
Analytical Group	**TPH-g**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8260B Laboratory SOPs: ANA8260
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015B and ANA8260.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8015B and ANA8260. MSD or Matrix Duplicate: RPD of all analytes ≤30%.	Examine the PQOs. Notify laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.

Matrix	**Soil and Water**
Analytical Group	**TPH-g**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8260B Laboratory SOPs: ANA8260
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Surrogate spike	All field and QC samples.	Per DoD QSM 5.3 (DoD and DOE 2019), Methods 8015C/8260c and ANA8082.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Trip blank	One per cooler.	Target analytes ≤1/2 LOQ.	Reanalyze for confirmation through a second analysis of the trip blank. Examine the PQOs.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Bias, Representativeness/ Contamination	Target analytes ≤1/2 LOQ.

%	percent
CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
GC	gas chromatography
GRO	gasoline range organics
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TPH	total petroleum hydrocarbons

Matrix	**Soil and Water**
Analytical Group	**TPH-d, TPH-o with and without Silica Gel Cleanup**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015B Laboratory SOPs: ANA8015
Analytical Organization	ANA8015

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by ANA8015.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by ANA8015 and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.

Matrix	**Soil and Water**
Analytical Group	**TPH-d, TPH-o with and without Silica Gel Cleanup**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015B Laboratory SOPs: ANA8015
Analytical Organization	ANA8015

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015B and ANA8015.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8015B and ANA8015. MSD or Matrix Duplicate: RPD of all analytes ≤30%.	Examine the PQOs. Notify Laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8015B and ANA8015.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

CCV	continuing calibration verification	MB	method blank
DoD	Department of Defense	MS	matrix spike
DQI	data quality indicator	MSD	matrix spike duplicate
DQO	data quality objective	QA	quality assurance
DRO	diesel range organics	QC	quality control
EPA	Environmental Protection Agency, United States	QSM	Quality Systems Manual
LCS	laboratory control sample	RPD	relative percent difference
LOD	limit of detection	RT	retention time
LOQ	limit of quantitation	SOP	standard operating procedure
LRO	lube oil range organics	TPH	total petroleum hydrocarbons

Matrix	**Soil and Water**
Analytical Group	**SVOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D Laboratory SOPs: ANA8270
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified byANA8270.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by ANA8270 and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Performance check	Before initial calibration and sample analysis, and at the beginning of each 12-hour shift.	Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses, and will not exceed a tailing factor of 2.	Correct problem, then repeat performance checks.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	Degradation of DDT must be ≤20%; and benzidine and pentachlorophenol must be present at normal responses and tailing factor is ≤2. No samples must be analyzed until performance check is within criteria.
Tune Check	Prior to the initial calibration and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of DFTPP.	Retune instrument and verify.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No sample will be analyzed without a passing tune.

Matrix	**Soil and Water**
Analytical Group	**SVOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D Laboratory SOPs: ANA8270
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM 5.3 Appendix C Limits, Method SW-846 8270D and ANA8270.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ± 10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM 5.3 Appendix C Limits, Method SW-846 8270D andANA8270.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

Matrix	**Soil and Water**
Analytical Group	**SVOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D Laboratory SOPs: ANA8270
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per matrix per analytical method for each batch of at most 20 samples.	Per DoD QSM 5.3 Appendix C Limits, Method SW-846 8270D and ANA8270. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify Laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

%	percent
CCV	continuing calibration verification
DDT	dichlorodiphenyltrichloroethane
DFTPP	decafluorotriphenylphosphine
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
SVOC	semivolatile organic compound

Matrix	**Soil and Water**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270DSIM Laboratory SOPs: ANA8270SIM
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by ANA8270SIM.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified ANA8270SIM and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Tune Check	Prior to the initial calibration and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of DFTPP or BFB from method.	Retune instrument and verify.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.
Performance check	Before initial calibration and sample analysis, and at the beginning of each 12-hour shift.	Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses, and will not exceed a tailing factor of 2.	Correct problem, then repeat performance checks.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	Degradation of DDT must be ≤20%; and benzidine and pentachlorophenol must be present at normal responses and tailing factor is ≤2. No samples must be analyzed until performance check is within criteria.

Matrix	**Soil and Water**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270DSIM Laboratory SOPs: ANA8270SIM
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8270DSIM and 8270SIM.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ± 10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8270DSIM and Laboratory SOP ANA8270SIM.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

Matrix	**Soil and Water**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270DSIM Laboratory SOPs: ANA8270SIM
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8270DSIM and ANA8270SIM. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

%	percent
BFB	4-bromofluorobenzene
CCV	continuing calibration verification
DDT	dichlorodiphenyltrichloroethane
DFTPP	decafluorotriphenylphosphine
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
PAH	polynuclear aromatic hydrocarbon
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SIM	selective ion monitoring
SOP	standard operating procedure

Matrix	**Soil and Water**
Analytical Group	**Dioxins/Furans (PCDDs/PCDFs)**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8290A Laboratory SOPs: HPL8290
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Resolving power (tuning)	Prior to initial calibration and at the beginning and end of each 12-hour period.	Using PFK and a molecular leak, static resolving power must be ≥10,000 (10% valley) for identified masses.	Retune instrument and verify. No samples will be analyzed without a passing tune check. Rerun affected samples since the last acceptable check.	Analyst Laboratory QA Officer	Sensitivity	QC acceptance criteria as specified by HPL8290 and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Performance check	Prior to ICAL or calibration verification. At the beginning of each 12-hour period during which samples or calibration solutions are analyzed.	Peak separation between 2,3,7,8-TCDD and other TCDD isomers: Resolved with a valley of ≤25%. Identification of all first and last eluters of the eight homologue retention time windows and documentation by labeling (F/L) on the chromatogram. Absolute retention times for switching from one homologous series to the next ≥10 seconds for all components of the mixture.	Correct problem then repeat column performance check.	Analyst Laboratory QA Officer	Accuracy	No standards or samples will be analyzed without a passing performance check.
EMPC	Every sample with a response S/N ≥2.5 for both quantitation ions.	Identification criteria per method must be met, and the S/N of response for both quantitation ions must be ≥2.5.	N/A.	Analyst Laboratory QA Officer	Accuracy	QC acceptance criteria as specified by HPL8290and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

Matrix	**Soil and Water**
Analytical Group	**Dioxins/Furans (PCDDs/PCDFs)**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8290A Laboratory SOPs: HPL8290
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis of each 12-hour period, and at the end of the analysis sequence.	Ion abundance specified in the method must be met. For unlabeled standards, RF within ± 20% D of RF established in ICAL; and for labeled standards, RF within ± 30% D of RF established in ICAL.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. End-of-run CCV: If the RF for unlabeled standards ≤25% RPD and the RF for labeled standards ≤35% RPD (relative to the RF established in the ICAL), the mean RF from the two daily CCVs must be used for quantitation of impacted samples instead of the ICAL mean RF value. If the starting and ending CCV RFs differ by more than 25% RPD for unlabeled compounds or 35% RPD for labeled compounds, the sample may be quantitated against a new initial calibration if it is analyzed within two hours. Otherwise, analyze samples with positive detections, if necessary.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected above the EML listed in the method or 1/3 the regulatory limit, whichever is greater.	Correct problem. If required, re-prep and reanalyze the MB and all samples in the associated batch for failed analytes, if sufficient material is available.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected above the EML or 1/3 the regulatory limit, whichever is greater.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8290 and HPL8290.	Correct problem. If required, re-prep and reanalyze the LCS and all samples in the associated batch for failed analytes, if sufficient material is available.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019), if available. Otherwise use in-house control limits.

Matrix	**Soil and Water**
Analytical Group	**Dioxins/Furans (PCDDs/PCDFs)**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8290A Laboratory SOPs: HPL8290
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
IS	Every field sample, standard, and QC sample.	% recovery for each IS in the original sample (prior to dilutions) must be within 40-135%, per method.	Correct problem, then re-prep and reanalyze the samples with failed IS.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Sample duplicate	One per analytical method for each batch of at most 20 samples.	RPD ≤25% (between sample and sample duplicate).	Examine the PQOs. Notify laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Precision	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8290 and HPL8290 MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

%	percent
CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EML	estimated maximum level
EMPC	estimated maximum possible concentration
IS	internal standard
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PFK	perfluorokerosene
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RF	response factor
RPD	relative percent difference
RT	retention time
S/N	signal-to-noise ratio
SOP	standard operating procedure

Matrix	**Soil and Water**
Analytical Group	**TOC**
Analytical Method/SOP Reference	Analytical Method: 9060A Laboratory SOPs: ANA9060 and ANA Walkley BLK
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by ANA9060 and ANA Walkley Blk.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by ANA9060 and ANA Walkley BLK, and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
MB	Each time samples are extracted.	No analytes detected >1/2 laboratory LOQ.	Correct problem, then re-prep and reanalyze the MB and all samples in the associated batch for failed analytes in all samples in the associated batch, if sufficient material is available.	Analyst Laboratory QA Officer Project Chemist	Sensitivity	QC acceptance criteria specified by laboratory and this project.
LCS	Each group of 20 or less.	QC acceptance criteria specified by laboratory.	Correct problem, then re-prep and reanalyze the LCS and all samples in the associated batch for failed analytes in all samples in the associated batch, if sufficient material is available.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria specified by laboratory and this project.

Matrix	**Soil and Water**
Analytical Group	**TOC**
Analytical Method/SOP Reference	Analytical Method: 9060A Laboratory SOPs: ANA9060 and ANA Walkley BLK
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Laboratory Duplicates	One per 20 samples.	RPD < 20%.	Associated samples will be qualified, if appropriate, during validation.	Data Validator/Project Chemist	Precision	RPD < 20.
Initial Demonstration of ability to generate acceptable accuracy and precision using four replicate LCS. (Total Organic Carbon only)	Once per analyst initially and annually thereafter.	Analyte within ± 20% of expected value and RSD < 20%.	Recalculate results: correct problem with system, then rerun demonstration.	Analyst Laboratory QA Officer	Precision/Accuracy	Per Method and Laboratory SOP.

%	percent
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
SOP	standard operating procedure
TOC	total organic carbon

Matrix	**Soil**
Analytical Group	**Particle Size Distribution (PSD)**
Analytical Method/SOP Reference	Analytical Method: ASTM D422 Laboratory SOPs: ASTM D422
Analytical Organization	APPL/Hushmand

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Duplicate	1 per 20 samples.	RPD ≤20%.	Examine the PQOs. Notify laboratory QA officer and the project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Precision	RPD ≤20%.

%	percent
ASTM	ASTM International
DQI	data quality indicator
DQO	data quality objective
QA	quality assurance
QC	quality control
RPD	relative percent difference
SOP	standard operating procedure

Matrix	**Groundwater**
Analytical Group	**Methane**
Analytical Method/SOP Reference	Analytical Method: RSK 175 Laboratory SOPs: ANARSK175
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by ANARSK175.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Laboratory SOP ANARSK175, and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails of if two consecutive CCVs cannot be run, perform corrective action(s); repeat CCB and all associated samples since last acceptable CCV. Alternatively, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.

Matrix	**Groundwater**
Analytical Group	**Methane**
Analytical Method/SOP Reference	Analytical Method: RSK 175 Laboratory SOPs: ANARSK175
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	One per preparation/analytical batch.	No target compounds ≥1/2 LOQ.	Re-extract or re-analyze samples associated with the MB.	Analyst Laboratory QA Officer	Accuracy/Bias	No target compounds ≥1/2 LOQ.
LCS	One per preparation/analytical batch.	75–125% of spiked concentration.	Re-extract or re-analyze samples associated with the LCS.	Analyst Laboratory QA Officer	Precision/Accuracy	75–125% of spiked concentration.
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method RSK 175 and ANARSK17. MSD or Matrix Duplicate: RPD of all analytes ≤30%.	Examine the PQOs. Notify laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).

CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
SOP	standard operating procedure

Matrix	**Groundwater**
Analytical Group	**Ferrous Iron, Anions, and Total and Dissolved Organic Carbon**
Analytical Method/SOP Reference	Analytical Method: SM3500-Fe B.4.c, SM4500-NO3 E, EPA 353.2, EPA 9056A, EPA9060A Laboratory SOPs: ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Laboratory SOP ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060, and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
CCV (as applicable)	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes within established RT windows. All reported analytes within ±10% of true value for methods.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails of if two consecutive CCVs cannot be run, perform corrective action(s); repeat CCB and all associated samples since last acceptable CCV. Alternatively, recalibrate if necessary; then reanalyze all associated samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.

Matrix	**Groundwater**
Analytical Group	**Ferrous Iron, Anions, and Total and Dissolved Organic Carbon**
Analytical Method/SOP Reference	Analytical Method: SM3500-Fe B.4.c, SM4500-NO3 E, EPA 353.2, EPA 9056A, EPA9060A Laboratory SOPs: ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	One per preparation/analytical batch.	No target compounds ≥1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Re-extract or re-analyze samples associated with the MB.	Analyst Laboratory QA Officer	Accuracy/Bias	No target compounds ≥1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.
LCS	One per preparation/analytical batch.	Per DoD QSM Appendix C Limits, and ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.	Re-extract or re-analyze samples associated with the LCS.	Analyst Laboratory QA Officer	Precision/Accuracy	Per DoD QSM 5.3 (DoD and DOE 2019). Appendix C Limits, and ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.
MS	One per analytical method for each batch of at most 20 samples.	Per Methods and ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.	Examine the project-specific DQOs. Notify laboratory QA Officer and Project Chemist as to additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Per Method and ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.
MSD	One per analytical method for each batch of at most 20 samples.	Per Methods and ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.	Examine the project-specific DQOs. Notify laboratory QA Officer and Project Chemist as to additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Per Method and ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.
Laboratory Duplicates	One per 20 samples.	RPD < 20%.	Associated samples will be qualified, if appropriate, during validation.	Data Validator/Project Chemist	Precision	RPD < 20.
Initial Demonstration of ability to generate acceptable accuracy and precision using four replicate LCS. (Total Organic Carbon only)	Once per analyst initially and annually thereafter.	Analyte within ± 20% of expected value and RSD < 20%.	Recalculate results: correct problem with system, then rerun demonstration.	Analyst Laboratory QA Officer	Precision/Accuracy	Per Method and ANA3500FeBC, ANA2320B, ANA353-2, HPL9056, and ANA9060.

CCV	continuing calibration verification	LOD	limit of detection	QA	quality assurance
DoD	Department of Defense	LOQ	limit of quantitation	QC	quality control
DQI	data quality indicator	MB	method blank	QSM	Quality Systems Manual
DQO	data quality objective	MS	matrix spike	RPD	relative percent difference
LCS	laboratory control sample	MSD	matrix spike duplicate	SOP	standard operating procedure

Matrix	**Groundwater**
Analytical Group	**Alkalinity and Total and Dissolved Silica**
Analytical Method/SOP Reference	Analytical Method: SM2320B and SM4500-SID Laboratory SOPs: ANA232B and ANA4500SiD
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by ANA232B and ANA4500SiD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by ANA232B and ANA4500SiD, and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
MB	One per preparation/analytical batch.	No target compounds ≥1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	Re-extract or re-analyze samples associated with the MB.	Analyst Laboratory QA Officer	Accuracy/Bias	No target compounds ≥1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.
LCS	One per preparation/analytical batch.	Per DoD QSM Appendix C Limits, Method SM2320B and SM4500-SID and Laboratory SOPs: ANA232B and ANA4500SiD.	Re-extract or re-analyze samples associated with the LCS.	Analyst Laboratory QA Officer	Precision/Accuracy	Per DoD QSM Appendix C Limits, Method SM2320B and SM4500-SID and ANA232B and ANA4500SiD.
MS	One per analytical method for each batch of at most 20 samples.	Per Methods and Laboratory SOPs ANA232B and ANA4500SiD.	Examine the project-specific DQOs. Notify laboratory QA Officer and Project Chemist as to additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Per Methods and Laboratory SOPs.

Matrix	**Groundwater**
Analytical Group	**Alkalinity and Total and Dissolved Silica**
Analytical Method/SOP Reference	Analytical Method: SM2320B and SM4500-SID Laboratory SOPs: ANA232B and ANA4500SiD
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	Measurement Performance Criteria
MSD	One per analytical method for each batch of at most 20 samples.	Per Methods and ANA232B and ANA4500SiD. RPD ≤30%.	Examine the project-specific DQOs. Notify laboratory QA Officer and Project Chemist as to additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Per Method and ANA232B and ANA4500SiD.
Laboratory Duplicates	One per 20 samples.	±20.	Associated samples will be qualified, if appropriate, during validation.	Data Validator/Project Chemist	Precision	±20.

CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
SOP	standard operating procedure

Matrix	**Groundwater**
Analytical Group	**Cation Metals**
Analytical Method/SOP Reference	Analytical Methods: EPA Method 6010C Laboratory SOPs: ANA6010
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Laboratory QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by QC018 and ANA6010.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.3 (DoD and DOE 2019).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by QC018/ANA6010, and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Initial and continuing calibration blank (ICB/CCB)	Before beginning a sample run, after every 10 field samples, and at the end of the analysis sequence.	No analytes detected >LOD.	Correct problem and repeat ICAL. All samples following the last acceptable calibration blank must be reanalyzed.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by ANA6010., and at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within ±10% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.

Matrix	**Groundwater**
Analytical Group	**Cation Metals**
Analytical Method/SOP Reference	Analytical Methods: EPA Method 6010C Laboratory SOPs: ANA6010
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	One per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Methods SW-846 6010C and Laboratory SOPs ANA6010.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
MS/MSD pair	One per MS pair per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Methods SW-846 6010C and Laboratory SOPs ANA6010 MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify laboratory QA officer and project chemist about additional measures to be taken.	Analyst Laboratory QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.3 (DoD and DOE 2019).
Dilution test	One per preparatory batch if MS or MSD fails. Only applicable to samples with concentrations >50× the LOQ prior to dilution.	Five-fold dilution must agree within ±10% of the original measurement.	Perform PDS addition.	Analyst Laboratory QA Officer Project Chemist	Accuracy/ Representativeness	QC acceptance criteria specified by DoD QSM 5.3 (DoD and DOE 2018). Diluted result is within ±10% of the original measurement.
PDS (ICP only)	One per preparatory batch when dilution test fails or analyte concentration in all samples <50 × LOQ prior to dilution. Use the same sample as used for the MS/MSD, if possible.	Recovery within 80–120%.	Run all associate samples in the preparatory batch by MSA.	Analyst Laboratory QA Officer Project Chemist	Accuracy/ Representativeness	QC acceptance criteria specified by DoD QSM 5.3 (DoD and DOE 2019). Recovery within 80–120%.
MSA	When dilution test or post digestion spike fails.	N/A.	N/A.	Analyst Laboratory QA Officer Project Chemist	Confirmation	N/A.

%	percent	ICP	inductively coupled plasma	PDS	post-digestion spike
CCB	continuing calibration blank	LCS	laboratory control sample	QA	quality assurance
CCV	continuing calibration verification	LOD	limit of detection	QC	quality control
DoD	Department of Defense	LOQ	limit of quantitation	QSM	Quality Systems Manual
DQI	data quality indicator	MS	matrix spike	RPD	relative percent difference
DQO	data quality objective	MSA	method of standard addition	RT	retention time
EPA	Environmental Protection Agency, United States	MSD	matrix spike duplicate	SOP	standard operating procedure
ICB	initial calibration blank	N/A	not applicable		

Matrix	**Sheen Sample**
Analytical Group	**C3–C44 Whole Oil**
Analytical Method/SOP Reference	Analytical/Preparation Method: ASTM D3328 Laboratory SOP: ASTM D3328
Analytical Organization	APPL

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Reporting limit establishment and verification	At initial setup: 1) Verify RL; and 2) Determine precision and bias at the RL. Subsequently, verify RL quarterly. If a laboratory uses multiple instruments for a given method, the RL must be verified on each.	1) The RL and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new RL must be demonstrated and reported.	If the RL verification fails, the laboratory must either establish a higher RL or modify method to meet the client-required precision and bias.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by ASTM D3328.
Resolution check	Before sample analysis.	Pristane and phytane resolution ≥80% for peak pairs n-C17 and pristane, and peak pairs n-C18 and phytane.	Correct problem, then repeat performance checks. If resolution is <50% either or both peak pairs, replace column and check instrument operating conditions.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	Pristane and phytane resolution ≥80% for peak pairs n-C17 and pristane, and peak pairs n-C18 and phytane. No samples must be analyzed until resolution check is within criteria.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 RL or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >RL.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Laboratory QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 RL or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >RL.
LCS/LCSD	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per ASTM D3328.	Correct problem. If required, re-prep and reanalyze the LCS/LCSD and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Laboratory QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by ASTM D3328.

LCSD	laboratory control sample duplicate

Worksheet #29: Project Documents and Records Table

Document [a]	Storage/Archive Location
Sample Collection Documents and Records	Storage: AECOM Technical Services, Inc. 1001 Bishop Street Suite 1600 Honolulu, HI 96813 Phone: 808-523-8874 Archive: Seattle Federal Records Center 6125 Sand Point Way, NE Seattle, WA 98115-7999 Phone: 206-336-5115
Field logbook (and sampling notes)	
Field sample forms (e.g., boring logs, sample log sheets, drilling logs)	
Chain of custody records	
Air Bills	
Photographs	
Field task modification forms	
Field sampling SOPs	
Laboratory documents and records	
Sample collection logs	
Health and safety sign in sheets	
Accident Prevention Plan acknowledgement	
Surveyed locations	
Communication logs	
Documentation of deviation from methods	
Drilling/Excavation permits	
Corrective action forms/documentation of the audits	
Documentation of internal QA review	
Identification of QC samples	
Meteorological data from field	
Sampling instrument calibration logs	
Sampling location and sampling plan	
Sampling report	
Analytical Records	
Chain of custody records	
Sample receipt forms and sample tracking forms	
Preparation and analysis forms and/or logbooks	
Tabulated data summary forms and raw data for field samples, standards, QC checks, and QC samples	
Case narrative	
Sample chronology (time of receipt, extraction, and analysis)	
Identification of QC samples	
Communication logs	
Corrective action reports	
Definitions of laboratory qualifiers	
Documentation of corrective action results	
Documentation of laboratory method deviations	
Electronic data deliverables	
Instrument calibration reports	
Laboratory sample identification numbers	

Document [a]	Storage/Archive Location
Reporting forms, completed with actual results	Storage: AECOM Technical Services, Inc. 1001 Bishop Street Suite 1600 Honolulu, HI 96813 Phone: 808-523-8874 Archive: Seattle Federal Records Center 6125 Sand Point Way, NE Seattle, WA 98115-7999 Phone: 206-336-5115
Signatures for laboratory sign-off (e.g., laboratory QA manager)	
Standards traceability records	
Project Data Assessment Records	
Field sampling audit checklists	
Analytical audit checklists	
Data review reports	
Telephone logs	
Corrective action reports	
Laboratory assessment	
Laboratory QA plan	
LOD study information	
DoD ELAP accreditation	
Offsite Analysis Documents and Records	
Chain of custody documents	
Laboratory Data Reports	
Third-Party Data Validation Reports	

DoD	Department of Defense
ELAP	Environmental Laboratory Accreditation Program
LOD	limit of detection
QA	quality assurance
QC	quality control
SOP	standard operating procedure

[a] All documents produced for the project will be kept in a secured facility for the life of the project. Upon closure of the project, laboratory data will be archived at the Federal Records Center in Seattle, Washington, and AECOM Technical Services, Inc. will retain copies of the project documentation for 10 years.

Worksheet #30: Analytical Services Table

All samples will be sent to Agriculture & Priority Pollutants Laboratories, Inc. Data packages will be due 21 days after samples are received at the laboratory. Data packages will be prepared according to NAVFAC Pacific Environmental Restoration Program Procedure I-A-7, *Analytical Data Validation Planning and Coordination* (DON 2015). Data packages must include, at a minimum, the following sections:

- Cover sheet
- Table of contents
- Case narrative
- Analytical results
- Sample management records
- Quality assurance/quality control information
- Information for third-party review, which includes all Raw Analytical Data

For complete details of hard copy and electronic data deliverable data package requirements, see Appendix C.

Sampling Locations	Matrix	Analytical Group	Reference SW-846, ASTM, SM Method	Laboratory SOP	Data Package Turnaround Time	Laboratory/Organization [a]	Backup Laboratory/Organization
OWDFMW02 (A&B) OWDFMW03 (A&B) OWDFMW04 (A) OWDFMW05 (A&B) OWDFMW06 (A&B) OWDFMW07 (A&B) OWDFMW08 (A&B)	Subsurface Soil (COPCs)	VOCs & TICs	8260B	ANA8260	10 Day TAT for Stage II Data and 15 Day TAT for Stage IV and EDD	APPL, Inc. 908 North Temperance Ave. Clovis, CA 96311 Libby Cheeseborough 559-862-2109	None Identified
		TPH-g	8260B	ANA8260			
		TPH-d/TPH-o	8015B	ANA8015			
		SVOCs & TICs	8270D	ANA8270			
		PAHs	8270SIM	ANA8270SIM			
		Dioxins/Furans	8290A	HPL8290			
	Subsurface Soil (Characteristics)	pH	9040C	ANA9040			
		TOC	9060	ANAWalkleyBlk			
		CEC	9081	ANA9081			
	Subsurface Soil (Geotechnical)	Atterberg limits	ASTM D4318	ASTM D4318	15 Day TAT for Geotechnical Report	APPL, Inc. 908 North Temperance Ave. Clovis, CA 96311 Libby Cheeseborough 559-862-2109	Hushmand Associates, Inc. 250 Goddard Irvine, CA 92618 949-777-1274
		Grain size distribution	ASTM D422	ASTM D422			
		Soil classification	ASTM D2488	ASTM D2488			
		Moisture content & density	ASTM D2216	ASTM D2216			
		Effective porosity & permeability	ASTM D7063	ASTM D7063			

Sampling Locations	Matrix	Analytical Group	Reference SW-846, ASTM, SM Method	Laboratory SOP	Data Package Turnaround Time	Laboratory/Organization [a]	Backup Laboratory/Organization
OWDFMW01 OWDFMW02 (A&B) OWDFMW03 (A&B) OWDFMW04 (A) OWDFMW05 (A&B) OWDFMW06 (A&B) OWDFMW07 (A&B) OWDFMW08 (A&B)	Groundwater	VOCs & TICs	8260B	ANA8260	10 Day TAT for Stage II Data and 15 Day TAT for Stage IV and EDD	APPL, Inc. 908 North Temperance Ave. Clovis, CA 96311 Libby Cheeseborough 559-862-2109	None Identified
		TPH-g	8260B	ANA8260			
		TPH-d/TPH-o	8015B	ANA8015			
		SVOCs & TICs	8270D	ANA8270			
		PAHs	8270SIM	ANA8270SIM			
		Dioxins/Furans	8290A	HPL8290			
	Groundwater Chemistry and Natural Attenuation Parameters	Anions	EPA 9056	ANA9056			
		Cations	EPA 6010A	ANA6010			
		Silica	SM4500-SID	ANA4500SiD			
		Methane	RSK175	ANARSK175			
		Organic carbon	9060A	ANA9060A			
		Alkalinity	SM2320B	ANA2320B			
		Nitrate-Nitrate Nitrogen	EPA 353.2	ANA353-2			
		Ferrous Iron	SM 3500-Fe	ANAN3500FEBC			
		TPH-d & TPH-o with Silica Gel Cleanup	8015B	LIQ001/CIN004/ANA8015			
Pending Field Observations and evaluation of data from Each Monitoring Well	NAPL or Sheen	Forensic and Fingerprinting Characterization/Evaluation	TPH-Characterization	ASTMD3328 or ASTMD5739	10 Day TAT for Stage II Data and 15 Day TAT for Stage IV and EDD	APPL, Inc. 908 North Temperance Ave. Clovis, CA 96311 Libby Cheeseborough 559-862-2109	None Identified
				MADEP VPH and EPH			
				TX1005 & 1006			
				EPA 8270SIM MOD			
				Selected Silica Gel Cleanup and analyses (TPH & SVOCs)			

EDD	electronic data deliverable
ID	identification
NAPL	nonaqueous-phase liquid
SOP	standard operating procedure
TAT	turnaround time

[a] Laboratory meets accreditation requirements to support project needs.

Worksheet #31: Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Action	Person(s) Responsible for Monitoring Effectiveness of Corrective Action
Review of field procedures	Daily	Internal	AECOM	Field Manager	Field Team Members	Field Manager	CTO Manager
Review of field notes/logbook	Weekly	Internal	AECOM	Field Manager/Field QC Coordinator	Field Team Members	Field Manager	CTO Manager
Review of field instrument calibration sheets	Daily	Internal	AECOM	Field Manager	Field Team Members	Field Manager	CTO Manager
Review of COC forms	Daily	Internal	AECOM	Project Chemist	Field QC Coordinator	Field Manager/Field QC Coordinator	CTO Manager
Field audit	Once	Internal	AECOM	Quality Assurance Manager	CTO Manager/ Field Manager	Field Manager	CTO Manager/Field Manager
Laboratory data assessment	Once per SDG	External/ Internal	MECx/ AECOM	Third-Party Data Validator/Project Chemist	Laboratory Project Manager	Laboratory Project Manager	Third-Party Data Validator/Project Chemist

AECOM	AECOM Technical Services, Inc.
COC	chain of custody
CTO	contract task order
QC	quality control
SDG	sample delivery group

Worksheet #32: Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response [a]	Timeframe for Response
Review of field procedures	Verbal communication/ logbook record	CTO Manager	Immediate	Logbook entry	CTO Manager	24 hours after notification
Review of field notes/logbook	Logbook record	CTO Manager	Immediate	Logbook entry	CTO Manager	24 hours after notification
Review of field instrument calibration sheets	Logbook record	CTO Manager	Immediate	Logbook entry	CTO Manager	24 hours after notification
Review of COC forms	Logbook record	Field Manager	Immediate	E-mail	QC Coordinator/ Field Manager	24 hours after notification
Field audit	Written audit report	CTO Manager/ Field Manager	72 hours after audit	Letter	Quality Assurance Manager	24 hours after notification
Laboratory data assessment	Verbal communication or e-mail	CTO Manager/Laboratory Project Manager	24 hours after notification	Letter or e-mail	Third-Party Data Validator/ Project Chemist	24 hours after notification

COC	chain of custody
CTO	contract task order
QC	quality control

[a] Copies of all assessment findings and corrective action responses will be provided to the Naval Facilities Engineering Systems Command remedial project manager.

Worksheet #33: Quality Assurance Management Reports Table

Type of Report	Frequency	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Third-Party Data Validation Report	Once, after submission of each sampling delivery group from the analytical laboratory	14 days after laboratory deliverable is received	Data Validator, MECx	CTO Manager (AECOM) and RPM (Navy)
Third-Party DQAR	Once, after all data are generated	21 days after last laboratory deliverable is received	Data Validator, MECx	CTO Manager (AECOM) and RPM (Navy)
Field Audit Report	Once, during the initial 3 weeks of the field work	7 days after field audit is completed	Quality Assurance Manager, AECOM	CTO Manager (AECOM), CTO Field Manager (AECOM), and QA Manager (Navy)

AECOM	AECOM Technical Services, Inc.
CTO	contract task order
DQAR	data quality assessment report
NAVFAC	Naval Facilities Engineering Systems Command
QA	quality assurance
RPM	remedial project manager

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 [a]	Internal/External
Laboratory system audits	Determine whether the laboratory holds a current DoD ELAP certification for all analyses to be performed for the project.	Project Chemist (Brant Landers, AECOM)	Step I	Internal
Field procedures	Determine whether field procedures are performed in accordance with this WP and prescribed procedures.	QA Program Manager (Scott Lewis, AECOM)	Step I	Internal
Field logbook and notes	Review the field logbook and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the CTO manager and included in the Field Audit Report.	Field Manager (John [Jack] Kronen, AECOM)	Step I	Internal
Instrument calibration sheets	Determine whether instruments are calibrated and used in accordance with manufacturer’s requirements.	Project Chemist (Brant Landers, AECOM) & Data Validator (Elizabeth Wessling, MECx)	Step I	Internal & External
COC forms	Review COC completed forms and verify them against the corresponding packed sample coolers. A copy of each COC will be placed in the project file. The original COC will be taped inside the cooler for shipment to the analytical laboratory.	Project Chemist (Brant Landers, AECOM)	Step I	Internal
Sampling analytical data package	Verify all analytical data packages for completeness prior to submittal of the data to the data validator.	Project Manager (Libby Cheeseborough, APPL)	Step I	External
Analytes	Determine whether all analytes specified in Worksheet #15 were analyzed and reported on by the laboratory.	Project Chemist (Brant Landers, AECOM)	Step IIa	Internal
COC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist (Brant Landers, AECOM)	Step IIa	Internal
Laboratory data and WP requirements	Assess and document the performance of the analytical process. A summary of all QC samples and results will be verified for measurement performance criteria and completeness. Full Validation will be performed on 10% of the data and Standard Validation will be performed on 90% of the data. A report will be prepared within 21 days of receipt.	Data Validator (Elizabeth Wessling, MECx) & Project Chemist (Brant Landers, AECOM)	Steps IIa & IIb	Internal & External
VOCs	Complete Procedure II-B, *Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260* (DON 2015).	Data Validator (Elizabeth Wessling, MECx)	Step IIa	External
SVOCs and PAHs	Complete Procedure II-C, *Level C and Level D Data Validation for GC/MS Semivolatile Organics by SW-846 8270 (Full Scan and SIM)* (DON 2015).	Data Validator (Elizabeth Wessling, MECx)	Step IIa	External

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/External
Dioxins/Furans	Complete Procedure II-D, *Level C and Level D Data Validation for HRGC/HRMS Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by SW-846 8290* (DON 2015).	Data Validator (Elizabeth Wessling, MECx)	Step IIa	External
TPH	Complete Procedure II-H, *Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015* (DON 2015).	Data Validator (Elizabeth Wessling, MECx)	Step IIa	External
Wet Chemistry	Complete Procedure II-R, *Level C and Level D Data Validation for Wet Chemistry Analyses* (DON 2015).	Data Validator (Elizabeth Wessling, MECx)	Step IIa	External
Sampling plan	Determine whether the number and type of soil and groundwater samples specified in Worksheet #20 were collected and analyzed.	Project Chemist (Brant Landers, AECOM) & Field Manager (John [Jack] Kronen, AECOM)	Step IIb	Internal
Field QC samples	Establish that the number of QC samples specified in Worksheet #20 were collected and analyzed.	Project Chemist (Brant Landers, AECOM)	Step IIb	Internal
Project quantitation limits and data qualifiers	Establish that sample results met the project quantitation limits and qualify the data in accordance with Procedure II-A, *Data Validation Procedure* (DON 2015).	Data Validator (Elizabeth Wessling, MECx) & Project Chemist (Brant Landers, AECOM)	Step IIb	Internal & External
Validation report	Summarize outcome of data comparison to MPC in the WP. Include qualified data and an explanation of all data qualifiers.	Data Validator (Elizabeth Wessling, MECx))	Step IIa	External
Data Quality Assessment Report (DQAR)	Summarizes the QA/QC of the DATA according to PARCCS and the PQOs. Complete Procedure II-S, *Data Quality Assessment Report* (DON 2015).	Data Validator (Elizabeth Wessling, MECx))	Step IIa	External

%	percent
AECOM	AECOM Technical Services, Inc.
COC	chain of custody
CTO	contract task order
DoD	Department of Defense
DQAR	Data Quality Assessment Report
ELAP	Environmental Laboratory Accreditation Program
GC/MS	gas chromatography/mass spectrometry
HRGC	high-resolution gas chromatography
HRMS	high-resolution mass spectrometry
MPC	measurement performance criteria
PAH	polynuclear aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-p-furan
PQOs	project quality objectives
QA	quality assurance
QC	quality control
SIM	selective ion monitoring
SVOC	semivolatile organic compound
TPH	total petroleum hydrocarbon
VOC	volatile organic compound
WP	work plan

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

Worksheet #37: Usability Assessment

37.1 SUMMARY OF THE DATA USABILITY ASSESSMENT PROCESS

A systematic data quality assessment (DQA) process involving data verification steps and third-party data validation as specified in Worksheets #34-36 will be implemented to assess the usability of environmental sample data generated for this Site Assessment. The evaluation will consider any deviations from proposed field activities or sampling and handling procedures. The analytical results of the soil and groundwater sampling will be compared to the project quality objectives (PQOs) presented in Worksheets #12 and #28 to determine whether the measurement performance criteria (MPC) were met. Upon completion of the verification and validation processes the data quality indicators will be evaluated for each analytical group in terms of meeting MPC goals as expressed by the precision, accuracy, representativeness, comparability, and completeness (PARCC) criteria. Variances in QC parameters will be assessed in relation to the potential impacts upon the usability of the affected data and interpretation of field sampling results. The Site Assessment report will include discussions of any limitations on the use of project data from this assessment as well as potential impacts on the project decision statement process.

37.2 FIELD ACTIVITY AND DATA VERIFICATION SUMMARY

The AECOM field manager will be responsible for periodic internal reviews to verify that field sampling procedures, instrument calibrations, and other relevant activities are performed in accordance with the WP. A bound field logbook will be used to document deviations in the proposed field activities, changes in sampling locations, sample types, and other relevant issues.

The data verification process will include onsite data review against the WP requirements for completeness and accuracy per Worksheet #22 (SOP requirements for calibration, maintenance, and testing). In addition, the review process will verify that SOPs for field sampling and analysis were followed.

The COC records and field QC logbook will be examined for traceability of data from sample collection to the planned and requested analyses for environmental field and field QC samples (as specified in Worksheets #18, #19, and #20).

Upon receipt from the designated analytical laboratory, electronic data will be assessed for proper reporting format with respect to data fields and content.

37.3 DATA VALIDATION AND DATA QUALITY ASSESSMENT PROCESS

All analytical laboratory data results will be validated by a third-party data validation firm to assess method compliance, calibration frequency and acceptability, QC frequency and acceptability, and data usability. Approximately 10 percent of the analytical data will be validated according to Naval Facilities Engineering Systems Command (NAVFAC), Pacific Full Data Validation procedures and 90 percent of the analytical data will be validated according to NAVFAC Pacific Standard Data Validation procedures. The analytical data will be evaluated for quality assurance (QA) and QC based on the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015) and *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, Version 5.3 (DoD and DOE 2019).

Sample data not meeting the NAVFAC Pacific procedures and DoD QSM (DoD and DOE 2019) acceptance criteria will be qualified with an abbreviation, or flag, to indicate a deficiency with the data. These qualifier flags include: "J" as estimated; "U" as non-detected; "UJ" as estimated/non-detected; and "R" as rejected. Qualification codes will also be applied to the data to explain why the various data qualifiers (flags) were applied. The complete definitions of data qualifier flags and qualification codes are presented in Procedure II-A, *Data Validation Procedure* (DON 2015).

Once the data are reviewed and qualified according to the NAVFAC Pacific procedures and DoD QSM (DoD and DOE 2019), a DQA process will summarize the QA/QC evaluation of the data according to the PARCC criteria relative to the MPCs or PQOs in accordance with Procedure II-S, *Data Quality Assessment Report Procedure* (DON 2015). Precision is a measure of the agreement between or reproducibility of analytical results under a given set of conditions. Accuracy in the analytical sense is defined by the agreement between a determined concentration and the true value of the parameter and is used to identify bias in a given measurement system. Representativeness is a qualitative expression of the degree to which the sample data are characteristic of a population. Comparability is a qualitative measure of the equivalence between analytical data sets that is influenced by factors such as sample collection and handling techniques, matrix type, and analytical method. Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results.

A quantitative and qualitative assessment of the data will identify potential sources of error, uncertainty, and bias that may affect the overall usability. The PARCC criteria are then evaluated for each analytical fraction in relation to specific QC deviations and their effects on both individual data points and the analyses as a whole.

Appendix A:
Standard Operating Procedures
(on CD-ROM at end of document)

I. Field Procedures

- Procedure I-A Planning
  - Procedure I-A-5 Utility Clearance
  - Procedure I-A-6 Investigation-Derived Waste Management
  - Procedure I-A-7 Analytical Data Validation Planning and Coordination
  - Procedure I-A-8 Sample Naming
- Procedure I-B Sampling
  - Procedure I-B-1 Soil Sampling
  - Procedure I-B-2 Geophysical Testing
  - Procedure I-B-5 Surface Water Sampling
- Procedure I-C Well Construction and Well Development
  - Procedure I-C-1 Monitoring Well Installation and Abandonment
  - Procedure I-C-2 Monitoring Well Development
  - Procedure I-C-3 Monitoring Well Sampling
- Procedure I-D Miscellaneous Sampling
  - Procedure I-D-1 Drum Sampling
- Procedure I-E Soil and Rock Classification
- Procedure I-F Equipment Decontamination
- Procedure I-I Land Surveying

II. Data Validation Procedures

- Procedure II-A Data Validation
- Procedure II-B Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260
- Procedure II-C Level C and Level D Data Validation for GC/MS Semivolatile Organics by SW-846 8270 (Full Scan and SIM)
- Procedure II-D Level C and Level D Data Validation for HRGC/HRMS Polychlorinated Debenzodioxins (PCDDs) and Polychlorinated Debenzofurans (PCDFs) by SW-846 8290
- Procedure II-H Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015
- Procedure II-Q Level C and Level D Data Validation for Metals by SW-846 6000/7000
- Procedure II-R Level C and Level D Data Validation for Wet Chemistry Analyses
- Procedure II-S Data Quality Assessment Report

III. QC Procedures

Procedure III-A Laboratory QC Samples (Water, Soil)

Procedure III-B Field QC Samples (Water, Soil)

Procedure III-D Logbooks

Procedure III-E Record Keeping, Sample Labeling, and Chain-of-Custody

Procedure III-F Sample Handling, Storage, and Shipping

Other Procedures

Greenwaste Policy (Dated 29 Oct 18)

Utility Clearance

1. Purpose

This standard operating procedure describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials. The procedure applies to the following activities: soil gas surveying, excavating, trenching, drilling of borings and installation of monitoring and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities. The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

2. Scope

This procedure applies to all United States Navy Environmental Restoration (ER) Program projects performed in the Naval Facilities Engineering Command, Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 UTILITY

For this procedure, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

3.2 AS-BUILT PLANS

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

3.3 ONE-CALL

The Utility Notification Center is the one-call agency for Oregon, Washington, Montana, and Hawaii. The Utility Notification Center is open 24 hours a day, and accepts calls from anyone planning to dig in. The phone number for the Hawaii One Call Center is 1-866-423-7287 (or 811). Additional information can be found at http://www.callbeforeyoudig.org/hawaii/index.asp.

Calling before you dig ensures that any publicly owned underground lines will be marked, so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines, but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a request is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address.
- What type or work is being done. This should be a description of the specific reason for the work, not the method used.
- Who the work is being done for.
- The county and city the work is taking place in.
- The address or the street where the work is taking place.
- Marking instructions, (specific instructions as to where the work is taking place).

Under normal circumstances it takes between 2 days to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested, but must be handled via voice contact with One-Call.

3.4 TONING

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned.

4. Responsibilities

The prime contractor CTO Manager is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The onsite Field Manager (FM) and Site Safety and Health Officer (SSHO) are responsible for planning utility clearance and for locating and marking underground utilities according to this procedure.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Follow the following steps at all sites where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

5.1 PREPARE PRELIMINARY SITE PLAN

Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the work plan. Include as many of the cultural and natural features as practical in this plan.

5.2 REVIEW BACKGROUND INFORMATION

Search existing plan files to review the as-built plans and available geographic information system databases to identify the known location of utilities at the site. In addition, the contractor should contact the Navy RPM to obtain the most updated GIS layers. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the CTO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The CTO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.

Include the utility location information gathered during investigation (e.g., remedial investigation or remedial site evaluation) work in the project design documents for removal or remedial actions. In this manner, information regarding utility locations collected during implementation of a CTO can be shared with the other contractors during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the other contractor may have to perform.

Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.

During the pre-fieldwork interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

5.3 DIG PERMIT

Prior to all activities requiring excavation work that may disrupt utility services, vehicular or aircraft traffic flow, protection provided by fire and intrusion alarm systems, or routine activities at Navy bases (including Joint Base Pearl Harbor-Hickam and Naval Base Guam), as well as intrusive work at Marine Corps Base Hawaii, current procedures shall be followed. The dig permit process tries to identify, as much as practical, any known, potentially hazardous work condition related to excavation activities and is intended to prevent accidents. It also informs key Navy personnel of the digging work and coordinates the required work with these activities to minimize inconveniences (JBPHH 2013).

5.4 SITE VISIT – LOCATE UTILITIES – TONING

Prior to the initiation of field activities, the field task manager or similarly qualified staff personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.

Following the initial site visit by the FM, a trained utility locator will locate, identify, and tone all utilities depicted on the preliminary site plan. The locator should use appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. This may involve the use of surface geophysical methods (Procedure I-B-2, *Geophysical Testing*). At a minimum, use a utility locator, metal detector, and/or magnetometer; however, it is important to consider the possibility that non-metallic utilities or tanks might be present at the site. Use other appropriate surface geophysical methods, such as Ground Penetrating Radar, if non-metallic cultural features are likely to be present at the site. Clear proposed exploration areas of all utilities in the immediate area where subsurface exploration is proposed. Clearly tone all anomalous areas. Clearly identify all toned areas on the preliminary site plan. After toning the site and plotting all known or suspected buried utilities on the preliminary site plan, the utility locator shall provide the FM with a copy of the completed preliminary site plan. Alternatively, the FM or designee shall document the results of the survey on the preliminary site plan.

Report to the FM anomalous areas detected and toned that are in close proximity to the exploration or excavation areas. The FM shall determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate proposed exploration or excavation areas. If this is required, the FM or a similarly qualified individual shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In some instances, such as in areas extremely congested with subsurface utilities, it may be necessary to dig by hand to determine the location of the utilities.

5.5 PREPARE SITE PLAN

Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the Contracting Officer’s Representative (COR), the CTO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the COR to verify its accuracy prior to initiating subsurface sampling activities.

6. Records

Keep a bound field logbook detailing all activities conducted during the utility locating procedure. The logbook will describe any changes and modifications made to the original exploration plan. The trained utility locator shall prepare a report and keep it in the project file. Also keep a copy of the final site plan on file.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Joint Base Pearl Harbor-Hickam (JBPHH). 2013. *Dig Permit Requests.* JBPHH Instruction 11013.1. 15 March 2013.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-2, *Geophysical Testing.*

9. Attachments

None.

Investigation-Derived Waste Management

1. Purpose

This standard operating procedure describes the activities and responsibilities of the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific with regard to management of investigation-derived waste (IDW). The purpose of this procedure is to provide guidance for the minimization, handling, labeling, temporary storage, inventory, classification, and disposal of IDW generated under the ER Program. This procedure will also apply to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste generated during implementation of removal or remedial actions. The information presented will be used to prepare and implement work plans (WPs) for IDW-related field activities. The results from implementation of WPs will then be used to develop and implement final IDW disposal plans.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

This procedure focuses on the requirements for minimizing, segregating, handling, labeling, storing, and inventorying IDW in the field. Certain drum inventory requirements related to the screening, sampling, classification, and disposal of IDW are also noted in this procedure.

3. Definitions

3.1 IDW

IDW consists of all materials generated during site investigations that might be contaminated with chemicals of concern. IDW might consist of many types of potentially contaminated materials, including but not limited to, PPE, disposable sampling and decontamination equipment, investigation-derived soil, sludge, and sediment, well development and purge water, and decontamination fluids.

3.2 PPE

PPE, as defined in this procedure, refers to all disposable materials used to protect personnel from contact with potentially contaminated site media, such as inner and outer gloves, Tyvek suits and overboots, and disposable respirator cartridges. Non-consumable items, such as steel-toe boots, respirators, and hard hats are not included in this procedure.

3.3 DISPOSABLE SAMPLING EQUIPMENT

Disposable sampling equipment consists of all single-use equipment that might have come in contact with potentially contaminated site media, including sample bailers, Draeger air monitoring tubes, used soil sampling trowels and spatulas, plastic drop cloths, plastic bags and bucket liners, and sample containers from field analytical test kits.

3.4 INVESTIGATION-DERIVED SOIL, SLUDGE, AND SEDIMENT

Investigation-derived soil consists of all potentially contaminated soil that is disturbed as part of site investigation activities. The most commonly encountered form of IDW soil is drill cuttings brought to the ground surface by drilling. Other forms of disturbed soil, including trenching spoils and excess soil remaining from surface sampling, should not be stored as IDW. Excavated soil should be returned to its source if site conditions permit.

Investigation-derived sludge consists of all potentially contaminated sludge materials generated or disturbed during site investigation activities. Generated sludge might consist of drilling mud used or created during intrusive activities. Other sludge might include solvents or petroleum-based materials encountered at the bottom of storage tanks and grease traps.

Investigation-derived sediment consists of all potentially contaminated sediments that are generated or disturbed during site investigation activities. Generated sediments might include solids that settle out of suspension from well development, purge, or decontamination water (see Definitions 3.5 and 3.6) while stored in 55-gallon drums or during sample filtration. Disturbed sediments might also consist of catch basin sediments or excess sediment from surface water activities.

3.5 WELL DEVELOPMENT AND PURGE WATER

Development water consists of groundwater withdrawn from newly installed monitoring wells in preparation for well purging or pump testing. Monitoring well development methods are discussed in Procedure I-C-2, *Monitoring Well Development*.

Purge water consists of groundwater that is removed from monitoring wells immediately prior to sampling. Well purging methods are discussed in Procedure I-C-3, *Monitoring Well Sampling*. Groundwater derived during aquifer testing shall be addressed on a site-specific basis. Procedures for handling groundwater generated during aquifer testing shall be included in the WP or equivalent document for the CTO.

3.6 DECONTAMINATION FLUIDS

Decontamination fluids consist of all fluids used in decontamination procedures conducted during site investigation activities. These fluids consist of wash water, rinse water, and solvents used for the decontamination of non-consumable PPE, sampling equipment, and drilling equipment. Decontamination procedures are discussed in Procedure I-F, *Equipment Decontamination*.

3.7 NON-IDW TRASH

Non-IDW trash is all waste materials, such as waste paper, drink containers, food, and packaging, generated in the support zone that have not come in contact with potentially contaminated site media.

3.8 NON-INDIGENOUS IDW

Non-indigenous IDW consists of all waste materials from offsite sources that are generated in the transition or contamination reduction zones and have not come in contact with potentially contaminated site media. Non-indigenous IDW includes materials, such as PPE from “clean” field activities (e.g., field blank generation, water sampling events) and refuse from monitoring well installation (e.g., unused sections of well casing, used bentonite buckets, sand bags, and cement bags).

Non-indigenous waste does not include material/waste that is abandoned at the ER site (including the IDW waste storage area) by other parties not associated with the ER work. Disposal of abandoned material/waste in the vicinity of IDW is the responsibility of the property owner (e.g., Navy Region Hawaii) or party responsible for abandoning the material/waste. The ER contractor shall notify the Contracting Officer’s Representative (COR) of the situation as soon as possible so that recovery actions can be coordinated by the Government.

3.9 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) HAZARDOUS WASTE

Under the RCRA, a solid waste that is not excluded from regulation is defined as hazardous if it:

- Is “listed” as a hazardous waste in Chapter 40, Code of Federal Regulations (CFR), Parts 261.31 through 261.33
- Exhibits any of four hazardous “characteristics”—ignitability, corrosivity, reactivity, or toxicity (as determined using the Toxicity Characteristic Leachate Procedure [TCLP]) (40 CFR 261.20-24)
- Is subject to certain “mixture” or “derived-from” rules (40 CFR 261.3).

Under certain circumstances, petroleum- or polychlorinated biphenyl (PCB)-contaminated wastes are not considered RCRA hazardous when they only exhibit toxicity characteristic (40 CFR 261.4(b)(10) and 261.8). If IDW is determined to be RCRA hazardous waste, then RCRA storage, transport, and disposal requirements shall apply unless exempt.

3.10 RCRA LAND DISPOSAL RESTRICTIONS (LDR)

Land disposal, as defined in RCRA, is any placement of RCRA hazardous waste on the land in a waste pile, landfill, impoundment, well, land treatment area, etc. LDRs are regulatory restrictions placed on land disposal, including pre-treatment standards, engineered containment, capacity constraints, and reporting and permitting requirements.

3.11 AREA OF CONTAMINATION (AOC)

The U.S. Environmental Protection Agency (EPA) considers the RCRA AOC to be a single land-based disposal unit, usually a “landfill,” and includes non-discrete land areas in which there is generally dispersed contamination. Storing IDW in a container (i.e., portable storage devices, such as drums and tanks) within the AOC and returning it to its source, whether RCRA hazardous or not, does not trigger RCRA LDRs. In addition, sampling and direct replacement of wastes within an AOC do *not* constitute land disposal.

3.12 CERCLA HAZARDOUS SUBSTANCES

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances are listed in 40 CFR Table 302.4 and include substances regulated by the RCRA Subtitle C, Clean Water Act (CWA), Clean Air Act (CAA), and Toxic Substances Control Act (TSCA). The CFR is updated annually; therefore, the most recent CFR should be referenced for the CERCLA hazardous waste list.

CERCLA hazardous substances are defined independent of their concentration level (i.e., any detection of a listed CERCLA constituent is considered a “CERCLA hazardous substance”). “Reportable quantities” identified for chemicals in 40 CFR Table 302.4 concern only CERCLA and RCRA requirements for notification to EPA when a release has occurred; they do not dictate whether a chemical is a hazardous substance.

The definition of CERCLA hazardous substances excludes “petroleum, including crude oil or any fraction thereof;” natural gas; natural gas liquids; liquefied natural gas; and synthetic gas usable for fuel, unless specifically listed or designated under the act. Excluded fractions of crude oil contain hazardous substances, such as benzene, that are indigenous in those petroleum substances or that are normally mixed with or added to petroleum during the refining process. However, hazardous substances that are (1) added to petroleum after the refining process, (2) increase in concentration as a result of contamination of the petroleum during use, or (3) commingled with petroleum after a release to the environment, are not considered part of the petroleum exclusion provision, and therefore, are regulated under CERCLA. In addition, some waste oils are regulated under CERCLA because they are specifically listed.

The scope of CERCLA hazardous substances includes the smaller subsets of RCRA hazardous wastes, PCB Aroclors, and other constituents. Therefore, a RCRA hazardous waste is always considered a CERCLA hazardous substance for a CERCLA-driven response action; however, a CERCLA hazardous substance is not always a RCRA hazardous waste.

CERCLA only regulates releases or threats of releases of hazardous substances into the environment. If there is no evidence that (1) a release has occurred (based on site history, visual observations, background metals evaluation), (2) there is a threat of release (as from abandoned, discarded, or non-maintained chemical receptacles), or (3) the release has entered the environment (as defined below), then CERCLA does not regulate the constituent even though it is identified on the CERCLA hazardous substance list.

3.12.1 CERCLA Hazardous Substances: TSCA/PCBs

PCBs are a CERCLA hazardous substance. PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned in 1979. They have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. Although no longer commercially produced in the United States, PCBs may be present in products and materials produced before the 1979 PCB ban.

If PCBs are detected at concentrations equal to or greater than 50 parts per million (ppm), the sample is considered TSCA-regulated. Current PCB regulations can be found in the CFR at 40 761. The EPA Q and A Manual (EPA 2009), referring to CFR 761.61 explains PCB remediation waste must be managed and disposed of based on the concentration at which the PCBs are found. It is unacceptable to dilute the as-found concentration of the contaminated soil by mixing it with clean soil during excavation or other IDW management activities.

3.13 ENVIRONMENT

Environment means navigable waters, ocean waters, surface water, groundwater, drinking water supply, land surface or subsurface strata, and ambient air, within the U.S. or under federal jurisdiction (see Section 101(8) of CERCLA or 40 CFR 300.5 for complete definition).

3.14 ONSITE AREA

The CERCLA onsite area is defined in 40 CFR 300.400(e)(1) as an area that includes:

- AOC
- All suitable areas in very close proximity to the contamination that are necessary for the implementation of the response action

The delineation of the onsite area is further discussed in Volume 55 Federal Register (FR) Page 8688 and EPA guidance.

Neither CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan, nor RCRA define the terms “area of contamination” or “contamination.” However, the area of contamination is interpreted as containing “varying types and concentrations of contaminants” (55 FR 8760) that may or may not pose a risk to human health or the environment.

The onsite area may also include several noncontiguous aerial extents of contaminations if they share a common nexus (55 FR 8690).

3.15 OFFSITE AREA

The offsite area consists of all areas outside the onsite area.

3.16 CERCLA OFFSITE RULE

The CERCLA offsite rule (400 CFR 300.440) states that IDW containing CERCLA hazardous substances (at any concentration) must be stored, treated, or disposed of offsite only at facilities having current EPA approval to accept such CERCLA wastes. RCRA-permitted facilities (Subtitle C and D) must also have specific EPA approval to accept waste generated at a CERCLA site (even if the waste is RCRA hazardous).

With some restrictions, the offsite rule does not apply to the following:

- Wastes generated during non-CERCLA actions
- Treatability study samples

- Wastes generated during emergency response actions
- Laboratory samples

CERCLA allows IDW to be managed, stored, and disposed of onsite within or near the AOC without the need for EPA approval (i.e., CERCLA facility approval) or RCRA permits. If IDW is to be stored or disposed of on site, the onsite area (and the AOC) should be delineated on a figure in the project field book and revised, based on best professional judgment, as site data become available.

4. Responsibilities

The prime contractor CTO Manager is responsible for preparing WPs and IDW disposal plans and reports in compliance with this procedure, and is responsible for documenting instances of noncompliance. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for implementing this IDW procedure and ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. IDW Management Procedures

The procedures for IDW management in the field are described below.

5.1 PLANNING FOR IDW MANAGEMENT

The project team should begin planning for IDW issues early in the site investigation planning stage. The proper management of IDW involves all of the following tasks:

- Obtain Navy approval for a designated IDW storage area prior to commencement of field work
  - Complete Navy form, including IDW Tracking Sheet and provide to remedial project manager (RPM) for processing
- Waste generation and minimization
- Chemical screening and characterization of the waste
- Waste handling, storage, and associated maintenance in compliance with all regulations (prepare an IDW drum inventory, ensure storage areas are compliant with type of waste [double containment, TSCA requirements, etc.] maintain condition of drum and labeling, maintain safety and assess controls, comply with permit requirements [for offsite storage])
- Waste transport and disposal within required holding times
- Waste tracking, documentation, record keeping, and reporting

As part of IDW planning, the CTO Manager should consult with the COR and environmental regulatory agencies to clearly identify the primary federal or state regulatory authority that is driving the site investigation. This authority may be CERCLA, RCRA (Subtitle C), RCRA (subtitle I), TSCA, CWA, or an equivalent state program. The primary investigation authority and regulations promulgated under this authority set forth requirements for IDW management. These requirements may differ under the various response authorities. For CERCLA-driven actions, IDW storage and disposal should comply with all applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria to the extent practicable.

Lastly, the CTO Manager should consider the disposal criteria of the anticipated disposal facility when developing the sampling and analysis plan (SAP). Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Facility disposal criteria may dictate laboratory reporting limits.

If unknown waste is observed onsite, notify the project RPM and COR for further instructions.

5.2 IDW MINIMIZATION

Field managers (FMs) and their designates shall minimize the generation of onsite IDW to reduce the need for special storage or disposal requirements that might result in substantial additional costs and provide little or no reduction in site risks (EPA 1992b). Reduce the volume of IDW by applying minimization practices throughout the course of site investigation activities. These minimization strategies include substitution of biodegradable raw materials; using low-volume IDW-generating drilling techniques; where possible, returning excess material to the source location; using disposable sampling equipment versus generating more decontamination fluids from reusable sampling equipment; using bucket and drum liners; and separating trash from IDW.

Material substitution consists of selecting materials that degrade readily or have reduced potential for chemical impacts to the site and the environment. An example of this practice is the use of biodegradable detergents (e.g., Alconox or non-phosphate detergents) for decontamination of non-consumable PPE and sampling equipment. In addition, field equipment decontamination can be conducted using isopropyl alcohol rather than hexane or other solvents (for most analytes of concern) to reduce the potential onsite chemical impacts of the decontamination solvent. Select decontamination solvents carefully so that the solvents, and their known decomposition products, are *not* potentially RCRA hazardous waste, unless absolutely necessary.

Give priority to drilling methods that minimize potential IDW generation. Select hollow-stem auger and air rotary methods, where feasible, over mud rotary methods. Mud rotary drilling produces waste drilling mud, while hollow stem and air rotary drilling methods produce relatively low volumes of soil waste. Use small-diameter borings and cores when soil is the only matrix to be sampled at the boring location; however, the installation of monitoring wells requires the use of larger-diameter borings.

If possible, return soil, sludge, or sediment removed from borings, containment areas, and shallow test trenches to the source immediately after sampling and/or geological logging of the soils (EPA 1991, 1992b). Immediate replacement of solid waste in the source location during investigation activities avoids RCRA LDRs, which permit movement of IDW within the same AOC without considering land disposal to have occurred, even if the IDW is later determined to contain RCRA hazardous material (EPA 1991). Place soil IDW from borings and trenches on polyethylene sheeting (e.g., Visqueen) during excavation and segregate it by approximate depth and any apparent contamination (i.e., visible staining). Following excavation, replace the soil IDW from above the saturated layer into the boring or trench and compact it, if possible. Efforts should be made to return the waste to the approximate depth from which it was generated. Soil and sludge IDW generated at or below the saturated layer of a boring or trench should be placed in drums and not returned to the source area. Suspected contaminated soil and sludge IDW generated above the saturated layer of a boring or trench should not be returned below the saturated layer."

Often monitoring wells are constructed outside the area of concern for soil contamination to sample for potential groundwater contamination or collect characteristic background data. At these locations, soil cuttings generated from above the saturation zone may be immediately disposed of near the wellhead in a shallow pit covered with natural topsoil from the site, and compacted. Contain soil and sludge IDW generated at or below the saturated layer in drums.

Reduce the quantity of decontamination rinse water generated by using dedicated and disposable sampling equipment, such as plastic bailers, trowels, and drum thieves that do not require decontamination. In general, decontamination fluids, and well development and purge water should not be minimized because the integrity of the associated analytical data might be affected.

Minimize the storage of visibly soiled PPE and disposable sampling equipment IDW by implementing decontamination procedures. If, based upon the best professional judgment of the FM, the PPE and disposable sampling equipment can be rendered non-contaminated after decontamination, then double-bag the PPE and disposable sampling equipment and dispose of it off site at a (RCRA Subtitle D) municipal solid waste disposal facility at the end of each work day (EPA 1991, 1992b). Since the decontaminated waste does not contain CERCLA hazardous substances, it need not be disposed of at a CERCLA-approved disposal facility in accordance with the CERCLA offsite rule.

Bucket liners can be used in the decontamination program to reduce the volume of solid IDW generated, and reduce costs on larger projects. The plastic bucket liners can be crushed into a smaller volume than the buckets, and only a small number of plastic decontamination buckets are required for the entire project. The larger, heavy-duty, 55-gallon drum liners can be used for heavily contaminated IDW to provide secondary containment, and reduce the costs of disposal and drum recycling. Drum liners may extend the containment life of the drums in severe climates and will reduce the costs of cleaning out the drums prior to recycling.

All waste materials generated in the support zone are considered non-IDW trash. To minimize the total volume of IDW, separate all trash from IDW, seal it in garbage bags, and properly dispose of it off site as municipal waste at the end of each work day.

Keep excess cement, sand, and bentonite grout prepared for monitoring well construction to a minimum. FMs shall observe well construction to ensure that a sufficient, but not excessive, volume of grout is prepared. Some excess grout may be produced. Unused grout (that should not come in contact with potentially contaminated soil or groundwater) shall be considered non-hazardous trash, and the drilling subcontractor shall dispose of it off site. Surplus materials from monitoring well installation, such as scrap plastic sections, used bentonite buckets, and cement/sand bags that do not come in contact with potentially contaminated soil, shall be considered non-IDW trash, the drilling subcontractor shall dispose of it off site.

Following proper segregation procedures, as discussed in the next section, can minimize the quantity of contaminated IDW generated.

5.3 SEGREGATION OF IDW BY MATRIX AND LOCATION

It is necessary to properly segregate IDW in order to:

- Avoid commingling contaminated waste with clean waste, thereby creating a larger volume of waste that must be treated as contaminated
- Facilitate the sampling, screening, classification, and disposal of waste that may require different management methods

Take efforts to segregate IDW even when these activities will increase storage container and storage space requirements. These efforts will drastically reduce the sampling and documentation required for characterizing the waste and their associated costs.

In general, segregate IDW by matrix and source location and depth at the time it is generated. IDW from only one matrix shall be stored in a single drum (e.g., soil, sediment, water or PPE shall *not* be mixed in one drum). Groundwater and decontamination water should not be commingled; however, development and purge water from the same well may be stored together.

In general, IDW from separate sources should not be combined in a single drum or stockpile. Take efforts to segregate waste by increments of depth below ground surface. Most importantly, segregate soil IDW generated at or from below the saturated zone from soil generated above this zone (soil below this zone might be impacted by contaminated groundwater, whereas soil above the zone may be “clean”). Similarly, segregate soil above and below an underground storage tank (UST). Label each drum of soil to indicate the approximate depth range from which it was generated; this task may require cuttings to be segregated on plastic sheeting as they are generated or drums to be filled during the trenching or boring operation if this can be done in a safe manner.

It is possible that monitoring well development and purge water will contain suspended solids, which will settle to the bottom of the storage drum as sediment. Include significant observations on the turbidity or sediment load of the development or purge water in the logbook see Procedure III-D, *Logbooks* and Section 5.5). To avoid mixed matrices in a single drum (i.e., sediment and water), it may be necessary to decant the liquids into a separate drum after the sediments have settled out. This segregation may be accomplished during subsequent IDW sampling activities or during consolidation in a holding tank prior to disposal.

Place potentially contaminated well construction materials in a separate drum. No soil, sediment, sludge, or liquid IDW shall be placed in drums with potentially contaminated waste well construction materials. In addition, potentially contaminated well construction materials from separate monitoring wells shall not be commingled.

Store potentially contaminated PPE and disposable sampling equipment in drums separate from other IDW. Segregate PPE from generally clean field activities, such as water sampling, from visibly soiled PPE, double-bag it, and dispose of it off site as municipal waste. Disposable sampling equipment from activities, such as soil, sediment, and sludge sampling, includes plastic sheeting used as liner material in containment areas around drilling rigs and waste storage areas, disposable sampling equipment, and soiled decontamination equipment. If, according to the Field Manager's best professional judgment, the visibly soiled PPE can be decontaminated and rendered non-hazardous, then double-bag the decontaminated PPE and disposed of it off site as municipal waste (EPA 1991, 1992b). PPE and disposable sampling equipment generated on separate days in the field may be combined in a single drum, provided clean and visibly soiled IDW are segregated as discussed above.

IDW generated from the use of field analytical test kits consists of those parts of the kit that have come into contact with potentially contaminated site media, and used or excess extracting solvents and other reagents. Contain potentially contaminated solid test kit IDW in plastic bags and store it with contaminated PPE or disposable sampling equipment IDW from the same source area as soil material used for the analyses. Segregate the small volumes of waste solvents, reagents, and water samples used in field test kits, and dispose of it accordingly (based upon the characteristics of the solvents as described in this procedure). Most other test kit materials should be considered non-IDW trash, and be disposed of as municipal waste.

Store decontamination fluids in drums separate from groundwater and other IDW. If practical, decontamination fluids generated from different sources should not be stored in the same drum. If decontamination fluids generated over several days or from different sources are stored in a single drum, record information about the dates and IDW sources represented in the drum. Note this information in the field notebook, on the drum label (Section 5.4.3), and in the drum inventory (Section 5.5).

The FM and designated personnel should separate the liquid and sediment portions of the equipment decontamination fluid present in the containment unit used by the drilling or excavation field crew. The contents of this unit normally consist of turbid decontamination fluid above a layer of predominantly coarse-grained sediment. When the contents of the containment unit are to be removed for storage in IDW drums, the FM shall instruct the field crew to place as much of the liquid into drums as possible and transfer the remaining solids into separate drums. Note observations of the turbidity and sediment load of the liquid IDW in the field notebook, on the drum label (Section 5.4.3), and in attachments to the drum inventory (Section 5.5). It is likely that decontamination fluids will contain minor amounts of suspended solids that will settle out of suspension to become sediment at the bottom of IDW storage drums. As noted above, it may be necessary to segregate the drummed water from sediment during subsequent IDW sampling or disposal activities.

Documentation for waste storage containers should include IDW source and segregation information and be maintained as follows:

1. Field logbook should be updated, at least weekly, with all IDW drum additions – update storage area location map to include new drum position and drum number.

2. External drum log (hard copy and electronic copy) should be updated with each IDW drum addition (drum numbers, source, and generation date) and closure of drum (fill date).

5.4 DRUM FILLING, HANDLING, AND LABELING, AND INVENTORYING

Drum handling consists of those actions necessary to prepare an IDW drum for labeling. Drum labeling consists of those actions required to legibly and permanently identify the contents of an IDW drum.

5.4.1 Drum Filling

Each drum of solid IDW shall be completely filled, when possible. For liquid IDW, drums should be left with headspace of approximately 5 percent by volume to allow for expansion of the liquid and potential volatile contaminants.

5.4.2 Drum Handling

IDW shall be containerized using U.S. Department of Transportation-(DOT) approved drums. The drums shall be made of steel or plastic, have a 55-gallon capacity, be completely painted or opaque, and have removable lids (i.e., United Nations Code 1A2 or 1H2). Drums having removable lids with bung holes are preferred to facilitate verification of drum contents. Typically 55-gallon drums are used, however small drums may be used depending on the amount of waste generated. New steel drums are preferred over recycled drums. Recycled drums should not be used for hazardous waste, PCBs or other regulated shipments. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. For this scenario, consider the scheduling and cost-effectiveness of this type of bulk storage, treatment, and discharge system versus longer-term drum storage.

The Guam Environmental Protection Agency may require double-walled drums or other secondary containment for the storage of liquid IDW. For long-term IDW storage at other project locations, the DOT-approved drums with removable lids are recommended. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids. If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, select another drum lid with a sealing ring that is in sound condition.

To prepare IDW drums for labeling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and disposable sampling equipment. Label all IDW drums and place them on appropriate pallets prior to storage.

5.4.3 Drum Labeling

Proper labeling of IDW drums is essential to the success and cost-effectiveness of subsequent waste screening and disposal activities (see Attachment I-A-6-1 and Attachment I-A-6-2). Labels shall be permanent and descriptive to facilitate correlation of field analytical data with the contents of individual IDW drums. Label all IDW drums using the **three distinct labeling methods** described below to ensure durability of the information. These three methods are completing and affixing preprinted NAVFAC Pacific ER Program labels; marking information on drum surfaces with paint; and, affixing aluminum tags to the drum. **Use of the preprinted labels, painted labeling, and aluminum tags is *mandatory***. These methods are described below.

5.4.3.1 PREPRINTED LABELS

Complete **two** preprinted NAVFAC Pacific ER Program drum labels as described below and presented in Attachment I-A-6-1. Seal both labels in separate heavy-duty, clear plastic bags, or use permanent markers on weatherproof stickers, to prevent moisture damage.

1. Place one label on the outside of the drum with the label data facing outward. Affix the bag/sticker to the drum at the midpoint of the drum height using a sufficient quantity of adhesive tape (e.g., duct tape, packing/strapping tape) so the bag will remain on the drum as long as possible during storage.

2. Affix the second label (sealed as mentioned above) to the underside of the drum lid, sealing it inside the drum when the lid is replaced.

The use of two or more preprinted labels for outer IDW drum identification purposes should be considered as a short-term backup to the information on the aluminum tags discussed below.

Print the requested information legibly on the drum labels in black, indelible ink. Instructions for entering the required drum-specific information for each label field are presented below:

CTO: Enter the four-digit number of the CTO for the project during which the IDW was generated. Include any initial zeroes in the CTO number (e.g., CTO 0047).

Activity-Site: Enter the name of the Navy activity responsible for the project site (e.g., Naval Supply Center, Naval Facilities Engineering Command Hawaii) and the name of the site where the project is taking place (e.g., Orote, Landfill, Building [Bldg.] 18).

Drum#: Enter the drum identification number according to the convention described below.

(xxxx-AA-DMzzz);

Where:

xxxx	represents the four-digit CTO number
AA	represents the unique site identifier assigned by the CTO Manager for multiple site CTOs (e.g., for CTO 0047, OW denotes Old Westpac, OR denotes Orote)
DM	represents a *drum* identification number
zzz	the sequential drum number for the site, beginning with 001

Date Collected: Enter the date the IDW was generated and placed in the drum. If IDW was generated over a number of days, enter the start and end dates for the period.

Contents: Record the source identification number on the label. Enter a "√" in the box corresponding to the type of IDW placed in the drum. For "Soil" and "Water," use the line provided to record observations on the condition of the drum contents (e.g., diesel odor, high turbidity, specific liquid IDW type). Check "Solid Waste" for PPE and indicate that PPE is present in the drum. Check

“Other” for disposable sampling equipment and potentially contaminated monitoring well construction materials, and indicate the type of waste on the line provided.

Project Type: Enter a “√” in the box corresponding to the type of investigation. Choices are Remedial Investigation, RCRA Facility Inspection, UST, and Other. If “Other” is specified, indicate the type of project in the “Comments” area, as described below.

Comments: Enter any additional information regarding the drum contents that will assist individuals who will characterize and dispose of the contents of the drum. “Other” project types include Site Inspection, Feasibility Study, Removal/Remedial Action, and Emergency Response activity. In addition, use this space on the label to complete any descriptions that were too large to fit in preceding label fields, such as the turbidity of decontamination water or the site activities from which the PPE was generated.

For Information Contact: Enter the project COR activity / code, address, and phone number.

It is essential that all relevant information recorded on individual drum labels be repeated in the field notebook for later development of the drum inventory database (see Section 5.5 and Procedure III-D, *Logbooks*).

5.4.3.2 PAINTED LABELS

The second method for labeling drums is to paint label information directly on the outer surface of the drum. At a minimum, the information placed on the drum shall include the CTO number, the drum number (following the numbering convention given above), the source identification number and type, the generation date(s), and the telephone number provided at the bottom of the preprinted label appropriate for the project location. The drum surface shall be dry and free of material that could prevent legible labeling. Confine label information to the upper two-thirds of the total drum height. The top surface of the drum lid may be used as an additional labeling area, but this area should only be used *in addition* to the upper two-thirds of the sides of the drum. The printing on the drum shall be large enough to be easily legible. Yellow, white, black, or red paint markers (oil-based enamel paint) that are non-photodegradable are recommended to provide maximum durability and contrast with the drum surface.

5.4.3.3 ALUMINUM TAGS

The third method for labeling drums is to affix an aluminum tag to the drum with neatly printed information that shall consist of the **CTO number**, the **drum identification number**, the **type of contents**, the **generation date(s)**, the **source** identification number and type, and the **telephone number** provided at the bottom of the appropriate preprinted label. Attachment I-A-6-2 to this procedure presents an example of the aluminum tag, which shall measure approximately 1 inch by 3 inches, or larger. When a ballpoint pen is used to fill out the aluminum tag, the information is permanently recorded as indentations on the tag. A fine ballpoint pen shall be used, and block-printed lettering is required for legibility. Indentations on the tag shall be sufficiently deep to be legible after the label has been exposed to weathering for an extended period.

Complete aluminum tags after the drum has been sealed. Affix the tags to the drum using a wire, which passes through predrilled holes in the label and shall be wrapped around the bolt used to seal the drum lid. The wire is the most likely part of the aluminum tag to decay during exposure. Use of plastic insulated, copper-core electrical wire of appropriate diameter is recommended if long-term exposure to severe weathering is anticipated.

5.4.3.4 WASTE LABELS

Standard green and white non-hazardous and/or other hazardous waste stickers may be used in conjunction with, but not in lieu of, the above labeling procedures.

5.5 DRUM INVENTORY

Accurate preparation of an IDW drum inventory is essential to all subsequent activities associated with IDW drum tracking and disposal. Prepare an inventory for each project in which IDW is generated, stored, and disposed of. This information provided in the inventory report constitutes the results of preparing and implementing an IDW sampling, screening, characterization, and disposal program for each site.

The drum inventory information shall include 10 elements that identify drum contents and indicate their outcome. These elements are discussed in Sections 5.5.1 through 5.5.10.

5.5.1 Navy Activity (Generator)/Site Name

Inventory data shall include the Navy activity and the site name where the IDW was generated (e.g., Fleet Industrial Supply Center Pearl/Red Hill, Naval Magazine Headquarters/USTs).

5.5.2 CTO Number

Inventory data shall include the four-digit CTO number associated with each drum (e.g., 0089) and contract number as necessary.

5.5.3 Drum Number

Include the drum number assigned to each drum in the inventory database. Drum numbers shall adhere to the numbering convention presented in Section 5.4.3.1 (e.g., 0091-LF-DM006).

5.5.4 Storage Location Prior to Disposal

Include the storage location of each drum prior to disposal in the inventory database (e.g., Bldg. 394 Battery Disassembly Area, or Adjacent to West end of Bldg. 54). As part of the weekly inventory, a site visit to the IDW storage location shall be performed to observe the condition of the drums and covers. Drums and covers are considered acceptable when the integrity of the drums and covers are structurally intact, drum identification is legible, and the location of the drum storage is secure. An unacceptable classification will require recommendations to remedy the unacceptable classification.

5.5.5 Origin of Contents

Specify the source identification of the contents of each IDW drum in the inventory database (e.g., soil boring number, monitoring well number, sediment sampling location, or the multiple sources for PPE- or rinse water-generating activities).

5.5.6 IDW Type

Inventory data shall include the type of IDW in each drum (e.g., soil, PPE, disposable sampling equipment, sludge, sediment, development water, steam cleaning water, decontamination rinse water).

5.5.7 Waste Volume

Specify the amount of waste in each drum in the inventory database as a percentage of the total drum volume or an estimated percentage-filled level (e.g., 95 percent maximum for liquid IDW).

5.5.8 Generation Date

Inventory data shall include the date IDW was placed in each drum. If a drum contains IDW generated over more than one day, the start date for the period shall be specified in dd-mmm-yy format. This date is *not* to be confused with a RCRA hazardous waste accumulation date (40 CFR 262).

5.5.9 Expected Disposal Date

Specify the date each drum is expected to be disposed of as part of the inventory in mmm-yy format. This date is for the Navy's information only and shall not be considered contractually binding.

5.5.10 Actual Disposal Date

The actual drum disposal date occurs at the time of onsite disposal, or acceptance by the offsite treatment or disposal facility. Enter this date in the drum inventory data base only when such a date is available in dd-mmm-yy format.

Information required to complete all 10 of the inventory elements for the monthly inventory report described above and summarized in Attachment I-A-6-3, will be located on the IDW labels or provided by the CTO Manager.

Actual disposition of the IDW drum contents will be provided to the Navy.

5.6 IDW CLASSIFICATION

In general, the CTO Manager should follow IDW classification guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1991, 1992a). The IDW classification process consists of chemical screening and characterization of the waste.

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the type(s) and concentrations of chemicals present in the waste. To ensure that IDW is managed in compliance with these requirements and to evaluate disposal options, the CTO Manager should

- Directly sample and analyze the IDW or associate it with historical data, observed site conditions, and/or samples collected on site at the source of the waste
- Screen the waste to identify the maximum concentrations of individual chemicals in, or associated with, the waste

- Screen waste constituents against chemical background data, if available
- Characterize the waste based on regulated groups of chemical constituents present in the waste
- Screen waste constituents against risk-based health criteria, ARARs, and TBC criteria for onsite disposal, or disposal facility criteria for offsite disposal

Each of the above steps is distinct and should be performed separately to avoid potential mistakes in the IDW classification process. The following subsections discuss these steps in greater detail.

5.6.1 IDW Sampling and Chemical Screening

IDW should be screened to identify chemicals present in the waste and their maximum concentrations. Screening may be facilitated by (1) directly sampling the waste, (2) associating the waste with analytical results from samples collected at the source of the IDW (e.g., a well boring), (3) visual observation of the waste, (4) historical activity data from the site, or (5) a combination of these methods (e.g., association with limited sampling). Composite sampling may be required if the unit volume of IDW is non-homogeneous. Data from samples collected directly from the IDW should take precedence over associated site sample data when making waste management decisions. Procedure I-D-1, *Drum Sampling* discusses methods for drum sampling.

Typically, IDW is screened for chemicals of potential concern at the site and against background data if available. If IDW is generated from outside the suspected AOC (e.g., soil cuttings from the installation of a background monitoring well), assume it is clean, and dispose of it accordingly.

The CTO Manager should consider the disposal criteria of any offsite disposal facility anticipated to be used when developing the SAP. Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Direct sampling and analysis of the waste may be required for these other constituents. Some disposal facilities prefer to collect and analyze the samples themselves. In addition, disposal facility criteria may dictate laboratory reporting limits. When possible, the CTO Manager should coordinate sampling and data requirements with the disposal subcontractor and anticipated disposal facility. Such efforts may allow IDW sampling to be conducted while the field team is mobilized for the site investigation, rather than conducting a separate IDW sampling event later.

5.6.2 IDW Characterization

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the particular constituent or *group(s) of chemical constituents* present in the waste. Therefore, to ensure that IDW is managed in compliance with these requirements, characterize IDW based on the chemical screening results to determine whether any of the following regulated constituents are present in the waste:

- Petroleum hydrocarbons (regulated by RCRA Subtitle I when released from a UST; see 40 CFR Part 280)
- Hazardous wastes (regulated by RCRA Subtitle C; see 40 CFR 261-299)
- Non-hazardous, solid wastes (regulated by RCRA Subtitle D; see 40 CFR 257-258)

- Hazardous substances and commingled petroleum (regulated by CERCLA; see 40 CFR 300.400 and 302.4)
- PCBs (regulated by TSCA; see 40 CFR 700)
- Asbestos (regulated by CAA for disposal; see 40 CFR 61, Subpart M)
- Radioactive wastes (regulated by the Nuclear Regulatory Commission; see 10 CFR [various parts], 40 CFR, Subchapter F, and other applicable laws)

EPA regulations and guidance do not require IDW to be tested to properly characterize it. Instead waste may be characterized based on historical site data, site observations, analytical data from the source of the IDW, and professional judgment (EPA 1991). Specifically, the EPA has indicated that IDW may be assumed not to be "listed" wastes under RCRA unless available information about the site suggests otherwise (53 FR 51444). Similarly, RCRA procedures for determining whether waste exhibits RCRA hazardous characteristics do not require testing if the decision can be made by "applying knowledge of the hazard characteristic in light of the materials or process used" (40 CFR 262.11(c); EPA 1991). If applicable, the disposal plans and reports should state, "there is no evidence based on site data and observations that the IDW contains listed RCRA wastes or exhibits RCRA characteristics."

For soil IDW, the potential for exhibiting toxicity may be determined by comparing constituent concentrations in the waste against screening values that are 20 times the TCLP criteria as specified in Section 1.2 of EPA Method Solid Waste-846 1311 *Toxicity Characteristic Leaching Procedure* (EPA 2007). Otherwise, samples associated with the soil can be tested using the TCLP.

5.7 IDW STORAGE

In general, the CTO Manager should follow IDW storage guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992a).

Always store IDW in a manner that is secure, protected from weather, and protective of human health and the environment. It is preferable to store IDW within the AOC(s) or on site; however, the Navy may assign a specific IDW storage area away from the project site.

If the IDW is determined to be RCRA hazardous, then RCRA storage, transport, and disposal requirements may apply, including a limited **90-day** storage permit exemption period prior to required disposal. If onsite disposal is an option, store RCRA waste within the AOC so that RCRA LDRs will not apply in the future. LDRs may be triggered if the waste is stored within the onsite area, but outside of the AOC or if the waste is removed from and later returned to the AOC for disposal. The AOC concept does not affect the approach for managing IDW that did not come from the AOC, such as PPE, decontamination equipment and fluids, and groundwater. If RCRA hazardous, these wastes must be managed under RCRA and drummed and disposed of off site (EPA 1991).

RCRA waste should not be stored within the AOC prior to disposal when professional judgment suggests the IDW might pose an immediate or permanent public endangerment (EPA 1991b).

Offsite storage of CERCLA waste must comply with the CERCLA offsite rule (40 CFR 300.440).

If the IDW is determined to be TSCA-regulated, then TSCA storage requirements as described in CFR 764.65, transport, and disposal requirements apply, including a limited **30-day** storage period prior to required disposal. Storage requirements are as follows:

1. Storage facilities must provide an adequate roof and walls to prevent rain water from reaching the stored PCBs.
2. Storage facilities must provide an adequate floor that has continuous curbing with a minimum 6-inch-high curb.
3. Storage facilities must contain no drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area.
4. Storage facilities must provide floors and curbing constructed of continuous smooth and impervious materials to minimize penetration of PCBs.
5. Storage facilities must not be located at a site that is below the 100-year flood water elevation.
6. PCBs in concentrations of 50 ppm or greater must be disposed of within 1 year after being placed in storage.

PCB waste can also be stored in a RCRA-approved waste storage area for 30 days from date of generation.

NAVFAC Pacific requires that all CERCLA, RCRA, and other types of waste be removed from JBPHH areas within 90 days of its generation, particularly within the shipyard area, and 30 days of generation for TSCA waste. Efforts should also be made to dispose of IDW within the 30- and 90-day periods at other Navy installations, unless the IDW will be managed with remediation waste to be generated during a cleanup action in the near future. The Navy may approve extensions of the storage time limit for wastes that are non-hazardous on a project-specific basis.

5.7.1 Drum Storage

Implement drum storage procedures to minimize potential human contact with the stored IDW and prevent extreme weathering of the stored drums. Place all IDW drums upright on pallets before the drums are stored. RCRA storage requirements include the following: containers shall be in good condition and closed during storage; wastes shall be compatible with containers; storage areas shall have a containment system; and spills or leaks shall be removed as necessary.

Place all IDW drums generated during field activities at a single AOC or designated IDW storage area together in a secure, fenced onsite area to prevent access to the drums by unauthorized personnel. When a secure area is not available, place drums in an area of the site with the least volume of human traffic. At a minimum, place plastic sheeting (or individual drum covers) around the stored drums. Post signage at the IDW storage area stating that drums should not be removed from the area without first contacting the Navy COR.

Liquid IDW drums must be stored under secondary containment (either secondary containment pallets or handmade plastic sheeting/polyvinyl chloride frame containment) and all IDW drums (soil and water) must utilize secondary containment when stored within 15 feet of a surface water body or storm drain inlet.

Drums from projects involving multiple AOCs shall remain at the respective source areas where the IDW was generated. IDW should not be transferred off site for storage elsewhere, except under rare circumstances, such as the lack of a secure onsite storage area.

Implement proper drum storage practices to minimize damage to the drums from weathering and possible human exposure to the environment. When possible, store drums in dry, shaded areas and cover them with impervious plastic sheeting or tarpaulin material. Make every effort to protect the preprinted drum labels from direct exposure to sunlight, which causes ink on the labels to fade. In addition, store drums in areas that are not prone to flooding. Secure the impervious drum covers appropriately to prevent dislodging by the wind. It may be possible to obtain impervious plastic covers designed to fit over individual drums; nonetheless, repeat the labeling information on the outside of these opaque covers.

Drums in storage shall be placed with sufficient space between rows of drum pallets and shall not be stacked, such that authorized personnel may access all drums for inspection. Proper placement will also render subsequent IDW screening, sampling, and disposal more efficient when individual drum removal is necessary. It is recommended that IDW drums be segregated in separate rows/areas by matrix (i.e., soil, liquid or PPE/other).

If repeated visits are made to the project site, inspect the IDW drums to clear encroaching vegetation, check the condition and integrity of each drum, secondary containment if applicable, check and replace aluminum tags as necessary, and replace or restore the tarpaulin covers.

5.7.2 IDW Stockpiles

Consider IDW stockpiling only when a very large quantity of IDW will be generated. Segregate stockpiled IDW, and inventory it by source location and depth to the extent practicable. Stockpiling and media mixing should not be used as methods to dilute chemical concentrations in the waste. Line stockpiles on the bottom, cover it with sturdy plastic, and locate it in areas where weather elements (e.g., wind, rainfall runoff) will not cause migration of the waste. Never dispose of liquid IDW on a stockpile; drum or store liquid waste in other appropriate containers. Follow applicable regulation and guidance when sampling stockpiled waste for characterization purposes.

5.8 IDW DISPOSAL

Various methods and requirements for onsite and offsite disposal of IDW are discussed in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992b). This section explains the disposal evaluation process and highlights some of the more important requirements for onsite and offsite IDW disposal options.

IDW sampling, characterization, and disposal analysis, particularly for onsite disposal, can be unexpectedly complex and require compliance with many different laws (that act as ARARs for IDW management and disposal). Before preparing the IDW disposal plan, compare estimated costs for onsite vs. offsite disposal. Offsite disposal may be more cost effective than devising and documenting the justification for onsite disposal when the quantity of IDW is small (less than 10 drums) and/or the waste fails the initial conservative screening against conservative risk-based criteria. Also weigh cost savings against the policy preference of the EPA and State of Hawaii Department of Health to manage and dispose of IDW on site, when possible.

5.8.1 Onsite Disposal

In general, the EPA preference is to dispose of IDW on site when the disposal action:

- Does not pose an unacceptable long-term risk to human health and the environment
- Is in accordance with chemical-, location- and action-specific ARARs “to the extent practicable” (40 CFR 300.415(i); 55 FR 8756)
- Does not introduce contaminants into clean soil or other site media
- Does not mobilize or significantly increase concentrations of any hazardous constituents already present in the environment
- Is consistent with the final remedy planned for the site
- Takes into account any community concerns regarding waste storage and the disposal method

Base onsite disposal options on best professional judgment and available site-specific data. For some projects, it may be prudent to store the waste temporarily until additional site data become available (e.g., sample analytical data, preliminary risk-assessment results, AOC delineation, and establishment of background values). Factors to consider include, but are not limited to the following:

- The detected or suspected contaminants, their concentrations, and total volume of IDW
- Media potentially affected (e.g., groundwater drinking source)
- Background metals data for site media
- Site access, conditions, and potential receptors
- Current and future land use
- Public perceptions (especially if drum storage and/or disposal takes place in open view)
- Time limits for IDW storage
- Potential requirements to treat waste before disposing of it on site
- Lack of unpaved areas to disposed of waste on site
- Potential wind, erosion, runoff, or flood conditions that might cause offsite migration of disposed waste
- Proximity to the ocean, surface water, or environmentally sensitive habitats
- Natural attenuation processes
- Need for additional utility survey before excavating to backfill waste
- Need for land use controls required to limit exposure pathways (e.g., backfill waste, provide permanent security around site, replant site to prevent erosion)

Protection of human health can be evaluated by comparing chemical concentrations in the waste to the more conservative of EPA residential regional screening levels), environmental action levels, and chemical-specific ARARs and TBC criteria. Ecological receptors can be protected by screening the IDW against EPA ecological soil screening levels. Onsite disposal of surface and groundwater IDW can be evaluated by initially screening against EPA tap-water PRGs, State Safe Drinking Water Standards (maximum contaminant levels and non-zero maximum contaminant level goals), and/or State Surface Water Quality Standards. These criteria are not always ARARs for the disposal method or site conditions; however, they may be useful to affirmatively show that the disposal is protective. Alternatively, the IDW may be associated with human-health and eco-risk assessment results for the site if the onsite placement of IDW is consistent with exposure pathway assumptions made during the risk assessment (e.g., contaminated soil might not present an unacceptable health risk at depth, but could pose such a risk if disposed of at the ground surface).

In general, return IDW consisting of environmental media to or near its source, and return waste generated from depth to its original depth, if possible and approved by NAVFAC in advance. Bury all contaminated soil and water IDW to be disposed of on site below grade at a depth of at least 3 feet and cover it with clean soil to reduce the potential for future exposure to human and ecological receptors.

Dispose of non-indigenous IDW and contaminated decontamination fluids off site. The cleaning detergent Alconox, often used in the decontamination process, is itself non-hazardous and biodegradable. Small quantities of clean decontamination water containing Alconox may be disposed of to clean areas on site. If onsite disposal is appropriate for RCRA IDW, this waste should be disposed of within the AOC to avoid the need to comply with LDRs.

IDW from several non-contiguous onsite areas may be consolidated and disposed of at one of the areas, provided a nexus exists between the wastes generated and response projects (55 FR 8690-8691).

IDW may also be temporarily disposed of back to the AOC without detailed analysis or documentation if the waste will be addressed with other site contamination during a future response action and will not present a significant short-term threat to human health and the environment.

5.8.2 Offsite Disposal

If onsite disposal is not a viable option, dispose of the IDW at an appropriate offsite treatment and/or disposal facility. Offsite transport and disposal of IDW must comply with all applicable laws and criteria specific to the chosen disposal facility. These requirements may include, but are not limited to the following:

- RCRA LDRs
- RCRA waste storage permits and time limits
- National Pollutant Discharge Elimination System and sewer disposal criteria
- CERCLA offsite rule
- TSCA treatment requirements
- DOT hazardous material transport packaging, manifesting, and security provisions

- International Maritime Organization ocean transport rules
- Certifications and training for waste transport contractors
- State notification requirements when importing certain types of waste

The CERCLA offsite rule (40 CFR 300.440) requires that CERCLA waste be disposed of only at facilities specifically approved by the EPA to receive such waste for treatment, storage, or disposal. The acceptability status of a disposal facility can change quickly (e.g., if there is a release at the facility); therefore, the CTO Manager should contact the EPA Region 9 CERCLA Offsite Rule Coordinator no more than 60 days prior to disposal of the IDW to verify the facility's approval status. The offsite rule applies to any CERCLA-driven remedial or removal action involving the offsite transfer of waste containing hazardous substances regardless of the concentrations present.

RCRA hazardous waste manifests must always be signed by authorized Navy personnel. In some cases, the Navy may authorize contractors to sign non-hazardous manifests. Navy authorization to allow contractor signature of non-hazardous manifests shall be based upon a Navy review of the contractor's RCRA and DOT training records. In addition, the Navy shall always be allowed the opportunity to review/approve non-hazardous manifests and waste profiles prior to waste disposal efforts.

Disposal of liquid IDW into the Navy sanitary sewer shall occur only if first approved by the Navy. Requests for disposal to Navy facilities should be coordinated through the COR. Discharge to the public sewer system is discouraged and should occur only if approved by state and local government agencies.

5.9 RECORDS

The CTO Manager is responsible for completing and updating the site-specific IDW drum inventory spreadsheet and submitting it as needed, and reviewing the IDW disposal plan (IDW disposal paperwork).

FMs and designates are responsible for documenting all IDW-related field activities in the field notebook including most elements of the IDW drum inventory spreadsheet. The correct methods for developing and maintaining a field notebook are presented in Procedure III-D, *Logbooks*.

Guidance related to preparing an IDW disposal plan (if required) is presented in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995).

5.9.1 IDW Disposal Documentation

Upon receipt of analytical data from the investigation or from IDW-specific analytical data, the generator information request form will be completed and provided to the IDW subcontractor to begin IDW characterization. Completed IDW disposal paperwork received from the IDW subcontractor should be reviewed for accuracy prior to submitting for Navy review.

The CTO Manager is responsible for submitting backup documentation (actual site or drum sampling results) along with the IDW disposal paperwork to the Navy.

Navy-approved contractor personnel may sign non-hazardous waste IDW documentation. Hazardous waste IDW documentation must be signed by an authorized Navy Environmental Coordinator.

All manifests (non-hazardous and hazardous) must be tracked, and if completed manifests (signed by disposal facility) are not received within 30 days of initial transportation, then contractor must notify the RPM weekly of the shipping status (e-mail is acceptable). Hazardous waste must be disposed of within 45 days of initial transportation. If not, specific IDW transportation details must be supplied to the Navy in order to prepare and file an exception report.

TSCA-regulated waste must be physically destroyed and or buried within 1 year of generation (date placed in IDW drum). Disposal certificates should be provided by the waste facility to the IDW subcontractor and Navy contractor.

Following disposal of IDW, the CTO Manager should prepare a short IDW disposal report summarizing the disposal operation and appending any associated records (e.g., final drum log, waste profiles, transport manifests, bills of lading, disposal facility certifications). Minimal topics to include in the report:

- IDW inventory and storage
- IDW chemical screening and characterization
- IDW transport and disposal
- Manifests
- Drum storage photographs
- Site figure

6. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

7. References

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Procedure I-C-3, *Monitoring Well Sampling*.

Procedure I-D-1, *Drum Sampling.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-D, *Logbooks.*

8. Attachments

Attachment I-A-6-1: IDW Drum Label

Attachment I-A-6-2: Drum Label – Aluminum Tag

Attachment I-A-6-3: Monthly IDW Drum Inventory Updates

Attachment I-A-6-1
IDW Drum Label

IDW Drum Label

Contract #:

CTO #:

ACTIVITY SITE: ______________________

DRUM # (_ _ _ _ - _ _ - D M _ _ _)

DATE COLLECTED

CONTENTS: (please ✓ and explain)

☐ Soil ______________________

☐ Water ______________________

☐ Solid Waste ______________________

☐ Other ______________________

PROJECT TYPE

☐ RI ☐ RFI ☐ UST ☐ Other

COMMENTS: ______________________

____

____

____

____

FOR INFORMATION CONTACT:

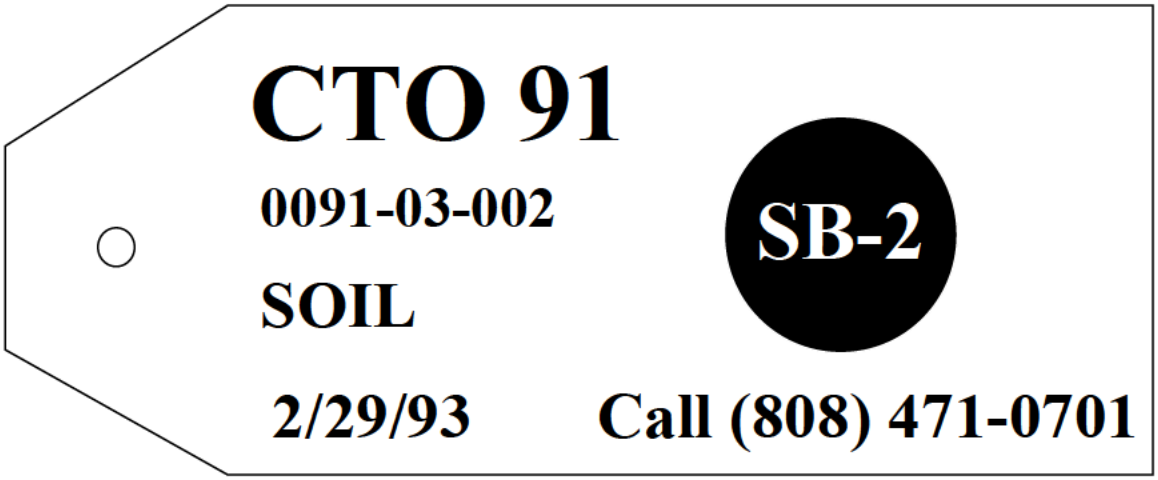
COR Activity/ Code:

Address:

Telephone:

Attachment I-A-6-2
Drum Label - Aluminum Tag

Drum Label - Aluminum Tag



Attachment I-A-6-3
Monthly IDW Drum Inventory Updates

Table I-A-6-1: Monthly IDW Drum Inventory Updates

Navy Activity / Site Name (Generator Site)	CTO Number (0bbb)	Drum Number (xxxx-AA-DMzzz)	Drum Storage Location	Origin of Contents (Source ID #)	IDW Type	Waste Volume (Fill level %)	Waste Generation Date (dd-Mon-yy)	Expected Disposal Date (Mon-yy)	Actual Disposal Date (dd-Mon-yy)
Inspector:									
Date of Inspection:									
NSC Pearl Harbor/ Landfill	0068	0068-LF-DM001	NSC, Bldg 7	SB-1	Soil Cuttings	100	16-Dec-92	Dec-93	N/A
		0068-LF-DM002	N/A	MW-1 MW-2 MW-3	Purge Water	75	20-Dec-92	Jul 93	26-Jul-93
		0068-LF-DM003	N/A	MW-1 MW-2 MW-3	Decon. Water	95	20-Dec-92	Jul-93	26-Jul-93
		0068-LF-DM004	NSC, Bldg.16	SB-1 SB-2 SB-3 SB-4 MW-1 MW-2 MW-3	PPE	50	16-Dec-92	Oct-93	N/A
NAVSTA Guam/ Drum Storage	0047	0047-DS-DM001	Hazmat Storage Area	SB-1 SB-2	Soil Cuttings	100	18-Feb-93	Sep-93	N/A

N/A Not Applicable

Analytical Data Validation Planning and Coordination

1. Purpose

This standard operating procedure describes data validation planning and coordination for all United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific sampling projects involving data validation.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 CRITICAL SAMPLES

Critical samples are samples that are especially important for assessing exposure and/or risk at a particular site, or are key in identifying remedial options.

3.2 DATA QUALITY ASSESSMENT REPORT

The data quality assessment report summarizes the QA/quality control (QC) evaluation of the data according to precision, accuracy, representativeness, completeness, and comparability relative to the Project Quality Objectives (PQOs). The report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

3.3 DATA VALIDATION

Data validation is a process that determines the technical usability of analytical data by comparison with a set of performance criteria. The performance criteria are designed in a manner that will enable the data user to know if the set of data will meet the intended purpose.

3.4 DATA VALIDATION STRATEGY

The data validation strategy includes the percentage of data to be validated (e.g., 100 percent or a smaller percentage), all samples from an entire sample delivery group (SDG) versus selected samples from various SDGs, and whether samples for Level D validation will be identified in advance or only after critical or risk-driving results for the risk assessment have been identified.

3.5 DATA VALIDATION LEVELS

The level of data validation possible for a given set of samples is based on the level of data package provided by the laboratory. The three levels of data validation considered are Level B (requires a Level 2 data package), Level C (requires a Level 3 data package), and Level D (requires a Level 4 data package). These levels have been identified in previous standard operating procedures as Cursory (Level B), Standard (Level C), and Full (Level D). Description for the extent of each level of data validation is presented below and further in Procedure II-A, *Data Validation*.

3.6 RAW DATA

Raw data is information that has not been processed, formatted, or reduced for end use. Examples of raw data include gas chromatographs, instrument printouts, copies of log books, chemist worksheets, etc.

3.7 SAMPLE DELIVERY GROUP (SDG)

A SDG, or analytical batch, typically includes up to 20 field samples plus associated batch QC samples.

4. Responsibilities

The prime contractor CTO Manager shall ensure coordination between data validators and appropriate project personnel. The CTO Manager is responsible for critical sample selection. The project chemist, laboratory coordinator, or other designated person, shall coordinate with the data validation task leader.

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

5. Procedures

An independent party who is not responsible for the generation of the data shall perform data validation. Section 5.1 discusses guidelines for selecting a data validation strategy, while Section 5.2 presents planning and coordination guidelines.

5.1 DATA VALIDATION STRATEGY SELECTION

Consult the Contracting Officer’s Representative, any appropriate regulatory agencies, and any Federal Facilities Agreements when choosing a data validation strategy. Clearly define the proposed level of effort for data validation in the project work plan. Based on the data validation requirements identified in the project planning documents, the analytical data may undergo “Level B,” “Level C,” or “Level D” data validation or some combination of these validation levels.

Guidelines for the required level of effort for data validation is described below and further in Procedure II-A, *Data Validation*.

5.1.1 Amount of Raw Data Acquired

It is recommended to request and obtain from the laboratory all raw data generated for the project sample analyses. While not all of the raw data will likely be reviewed, it is more time-efficient and cost-effective to obtain the data at the time of analysis than to request the laboratory to provide them at a later date. In addition, project chemists and risk assessors may use portions of the raw data to more fully evaluate analytical data. Attachment I-A-7-1 presents the laboratory analytical data reporting requirements that shall be followed for the NAVFAC Pacific Area of Responsibility.

For projects with quick turnaround time (TAT) requirements, one option is to receive results only for the quick TAT, while receiving the remaining data at the normal TAT. This will allow the laboratory more time to compile the entire data package. Consult project-specific PQOs to determine if this approach is feasible.

5.1.2 Level B Validation

Level B validation is the least intensive of the three levels of data validation and is appropriate for non-critical data. Level B validation consists of evaluating factors such as holding times, spike analyses, blank analyses, and field QC samples. Examples of analytical results evaluated under data review include data generated during compliance monitoring, field analytical testing, or investigation derived waste sampling.

5.1.3 Level C Validation

Level C validation is the intermediary of the three levels of data validation and is appropriate for critical samples used in decision making. Level C validation consists of evaluating factors such as holding times, instrument calibration, spike and blank analyses, and field QC samples. Level C validation may be performed on a percentage or all of the project data. The exact percentage of data to undergo Level C validation will depend on the project objectives. Examples of analytical results evaluated under Level C validation include data generated for risk assessments, removal action verification, remedial designs, etc.

5.1.4 Level D Validation

Level D validation is the most rigorous of the three levels of data validation and is appropriate for critical samples used in decision making. Level D validation consists of evaluating factors such as holding times, instrument calibration, spike and blank analyses, field QC samples, and raw data. Level D validation may be performed on a percentage or all of the project data. The exact percentage of data to undergo Level D validation will depend on the project objectives. Examples of analytical results evaluated under Level D validation include data generated for risk assessments, removal action verification, remedial designs, etc.

Depending on the objectives of the project, a representative portion of data shall be chosen for Level D validation by selecting random samples and analyses, or more practically, be selected by identifying certain representative SDGs. This may include selecting all samples and analyses from one of the first SDGs of field samples for Level D data validation, and also for SDGs with different matrices, subsequent phases of work/mobilizations, and for each laboratory if more than one is used.

Larger projects typically require lower frequencies of Level D validation than smaller projects. For example, a project with one SDG may require 100 percent Level D validation. For a CTO with five SDGs, the first SDG may require Level D validation with the remaining four SDGs validated at Level C.

If significant issues, as defined in the data validation procedures presented in Section II of this procedures manual, are noted during Level D validation, additional Level D validation above the originally planned percentage may be warranted and should be proposed. Additionally, the first several SDGs validated should be evaluated and corrective actions taken immediately if issues are identified.

5.2 PLANNING AND COORDINATION

During the planning and cost estimating stage of a project, contact the data validation task leader. Discuss the level of quality control, data validation strategy, number of samples per method, number of SDGs, schedule, and due dates. Copy all planning documents to the data validation task leader when they are completed (draft and final).

Hardcopy data validation reports are typically required and electronic entry of data qualifiers and qualification codes may be required if an analytical database is used for data interpretation.

Continuing coordination is critical. Notify the data validation task leader of any changes to the sampling schedule, analytical plan, or number of samples. Inform the data validators as well as the laboratory of every change from the chain of custody/analytical request form in sample numbers and/or requested analyses. Communicate changes to analytical methods agreed upon with the laboratory to the data validation task leader.

A schedule, which is updated as needed, is necessary to track the status of data validation activities. The prime contractor QA Manager or Technical Director shall coordinate and set priorities between CTOs. Attachment I-A-7-2 is an example of a form that may be used by CTO personnel to track the data validation status of hardcopy data.

A cross-reference list of field QC samples associated with site samples is required to validate data. This list must be provided by field personnel or from the chain-of-custody logbook (Procedure III–E, *Record Keeping, Sample Labeling, and Chain-of-Custody*).

6. Records

Data validation reports generated by data validators shall include content discussed in Procedure II-A, *Data Validation* and be included as an appendix in the report and summarized in the report. Changes in the schedule, number of samples, or analytical plan shall be sent to the data validators verbally and in writing.

The data validation effort shall be summarized for inclusion as a section of the report. It may also be helpful to summarize the data validation results in the form of a data quality assessment report (DQAR). The DQAR should summarize the net results of data validation for each QC parameter evaluated. It is recommended that precision, accuracy, and percent completeness objectives also be presented in the report. This task could be conducted by the data validators, or by project staff more familiar with the PQOs. The content and format of the DQAR is discussed in Procedure II-S, *Data Quality Assessment Report*.

As part of the summary, the project personnel shall ensure that all data requested for analysis and validation were actually analyzed and validated. Identification of rejected data (and the reasons) may be the most critical results. Data that have been qualified from detections to nondetections, or data for which numerical values have changed significantly, are also important. The summary may focus on the analytes and samples that are considered most critical for each project and include a summary of field QC results by field QC type.

7. Health and Safety

Not applicable.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Procedure II-A, *Data Validation*.

Procedure II-S, *Data Quality Assessment Report*.

Procedure III–E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

Attachment I-A-7-1: DoD QSM Appendix DoD A Reporting Requirements

Attachment I-A-7-2: Example Hardcopy Data Validation Status Tracking Form

Attachment I-A-7-1
DoD Quality Systems Manual Appendix DoD A Reporting Requirements

APPENDIX DOD-A – REPORTING REQUIREMENTS

In the absence of client specified reporting criteria, the reporting requirements outlined below shall be used for hard-copy data reports or electronic versions of hard-copy data (such as pdf). They include mandatory requirements for all printed data reports, and requirements for data reports requiring third party data review or validation. Optional reporting requirements are those that may be required by a specific project, depending upon their needs. The following elements are required: cover sheet, table of contents, case narrative, analytical results, sample management records, and Quality Assessment/Quality Control (QA/QC) information. Information for third-party review may be required depending on project-specific requirements or the method being used.

1.0 Cover Sheet

The cover sheet shall specify the following information:

- Title of report (i.e., test report, test certificate);
- Name and location of laboratory (to include a point of contact, phone and facsimile numbers, and e-mail address);
- Name and location of any subcontractor laboratories, and appropriate test method performed (information can also be located in the case narrative as an alternative);
- Unique identification of the report (such as serial number);
- Client name and address;
- Project name and site location;
- Statement of data authenticity and official signature and title of person authorizing report release;
- Amendments to previously released reports that clearly identify the serial number for the previous report and state the reason(s) for reissuance of the report; and
- Total number of pages.

2.0 Table of Contents

Laboratory data packages shall be organized in a format that allows for easy identification and retrieval of information. An index or table of contents shall be included for this purpose.

3.0 Case Narrative

A case narrative shall be included in each report. The purpose of the case narrative is to:

- Describe any abnormalities and deviations that may affect the analytical results;
- Summarize any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data; and
- Provide a summary of samples included in the report with the methods employed in order to assist the user in interpretation.

The case narrative shall provide (Information need not be repeated if noted elsewhere in the data package):

- A table(s) summarizing samples received, providing a correlation between field sample numbers and laboratory sample numbers, and identifying which analytical, preparation, and clean-up methods were performed. If multiple laboratories performed analyses, the name and location of each laboratory **shall** be associated with each sample;
- A list of samples that were received but not analyzed;
- Date of samples received;
- Sample preservation or condition at receipt;
- A description of extractions or analyses that are performed out of holding times;
- A definition of all data qualifiers or flags used;
- Identification of deviations of any calibration standards or QC sample results from appropriate acceptance limits and a discussion of the associated corrective actions taken by the laboratory;
- Identification of multiple sample runs with reason(s) identified (e.g., dilutions or multiple cleanups);
- Identification of samples and analytes for which manual integration was necessary; and
- Appropriate notation of any other factors that could affect the sample results (e.g., air bubbles in volatile organic compounds (VOC) sample vials, excess headspace in soil VOC containers, the presence of multiple phases, sample temperature or pH excursions, and container type or volume).

4.0 Analytical Results

The results for each sample shall contain the following information at a minimum: (Information need not be repeated if noted elsewhere in the data package):

- Project name and site location;
- Field sample ID number as written on custody form;
- Laboratory sample ID number;
- Preparation batch number(s);
- Matrix (soil, water, oil, air, etc.);
- Date and time sample collected;
- Date and time sample prepared;
- Date and time sample analyzed;
- Method numbers for all preparation, cleanup, and analysis procedures employed;
- Analyte or parameter with the Chemical Abstracts Service (CAS) Registry Number if available;

- Sample aliquot analyzed;
- Final extract volume;
- Identification of analytes in which manual integration occurred, including the cause and justification;
- Analytical results with correct number of significant figures;
- Detection Limit, Limit of Detection, and Limit of Quantitation associated with sample results and adjusted for sample-specific factors (e.g., aliquot size, dilution/concentration factors, and moisture content);
- Any data qualifiers assigned;
- Concentration units;
- Dilution factors;
- All multiple sample run results shall be reported;
- Percent moisture or percent solids (all soils are to be reported on a dry weight basis); and
- Statements of the estimated uncertainty of test results (optional).

5.0 Sample Management Records

Sample Management records shall include the documentation accompanying the samples, such as:

- Chain-of-custody records;
- Shipping documents;
- Records generated by the laboratory which detail the condition of the samples upon receipt at the laboratory (e.g., sample cooler receipt forms, cooler temperature, and sample pH);
- Telephone conversation or e-mail records associated with actions taken or quality issues; and
- Records of sample compositing done by the laboratory.

6.0 QA/QC Information

The minimum laboratory internal QC data package shall include:

- Method blank results;
- Percent recoveries for Laboratory Control Sample (LCS), Laboratory Control Sample Duplicates (LCSD), Matrix spike (MS), and Matrix Spike Duplicates (MSD);
- MSD or matrix duplicate Relative percent differences (RPD);
- Surrogate percent recoveries;
- Tracer recoveries;
- Spike concentrations for LCS, MS, surrogates;
- QC acceptance criteria for LCS, MS, surrogates;
- Post-Digestion Spike (PDS) recoveries;

- In-house or project specified LCS control limits, as applicable;
- Serial dilutions (SD) percent difference; and
- Batch numbers (preparation, analysis, and cleanup).

7.0 Data Reports for Third Party Review or Validation

When third party review or data validation is to be performed, the extent (stage) of data validation that can be performed is dependent upon the type (level) of data report delivered by the laboratory. The data report level and data validation stage required to meet project data quality objectives should be specifically defined in the QAPP.

The minimum reporting requirements for each level of data report are outlined below.

- A cover sheet, table of contents, and case narrative including all of the information specified in the above sections are required for all levels of data reports.
- **Level 1**: Analytical results, Sample Management Records.
- **Level 2**: **Level 1** reporting requirements plus QA/QC Information, Instrument QA/QC Information, Instrument and Preparation logs.
- **Level 3**: **Level 2** reporting requirements plus Instrument Quantitation Reports.
- **Level 4**: **Level 3** reporting requirements plus Instrument Chromatograms and Spectra.
- In addition, Standards traceability should be included in Levels 3 and 4 if a legal chain of custody is required.

The data validation guidelines established in other Department of Defense guidance or project-specific guidelines may have distinct reporting formats. The appropriate QAPP should be consulted to determine what type of data package is required.

Attachment I-A-7-2
Example Data Validation Status Tracking Form

Table I-A-7-2-1: CTO xxxx Data Validation Report Status Tracking Form

SDG	Due Date	VOCs Rec'd	PCBs Rec'd	TPH Rec'd	Metals Rec'd	Cr+6 Rec'd	Otin Rec'd	TOC Rec'd
DB360	7/30	7/21	8/21	8/21	8/7	X	8/23	5/25
DB383	7/30	7/21	8/21	8/21		X	8/23	5/25
DB401	6/15	6/9	6/9	6/9	6/9	X	7/7	6/9
DC160	8/15	7/21	8/21	8/21			X	8/7
DC180	8/15	7/21	8/21	7/23		7/21	8/23	8/21
CK0693	7/30	X	X	X	X	7/20	X	X
CK0694	7/30	X	X	X	X	7/20	X	X
CK0732	7/30	X	X	X	X	7/20	X	X
DC205	9/15		X			X	X	
DC209	9/15		X			X	X	
DB429	9/15		X			X	X	
DB439	9/15		X			X	X	X
DB458	9/15		X			X	X	X

PCB	polychlorinated biphenyl
TOC	total organic carbon
TPH	total petroleum hydrocarbons
VOC	volatile organic compound
7/21	date data validation report was received
X	no analysis for that method for that SDG
blank	data validation report not yet received

Sample Naming

1. Purpose

This standard operating procedure describes the naming convention for samples collected and analyzed, and whose resulting data will be stored in the database for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific projects. Unique sample names are used to facilitate tracking by laboratory personnel and project personnel, and for purposes of storing, sorting, and querying data in the database.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 CHAIN OF CUSTODY SAMPLE NUMBER

The chain of custody (COC) sample number is a five-character identification number that is used by the laboratory and project personnel for tracking purposes. A unique COC sample number must be used for each sample collected from a particular location at a particular time. It is useful for the first two characters to be letters unique to a particular site or project, while the remaining three characters may be digits from 001 to 999 (e.g., AA001). The COC sample number is the only identifier that should be presented to the laboratory.

3.2 SAMPLE IDENTIFICATION NUMBER

The sample identification number is a unique multi-alpha, multi-numeric identifier that is used by the field team to associate sampling results to the particular sampling location, sample type, number of times the location has been sampled, and depth. To avoid potential bias in sample analysis, the sample identifier is not provided to the laboratory. The sample identification number shall be recorded in the field logbook concurrently with the COC sample number.

4. Responsibilities

The prime contractor CTO Manager shall ensure that a proper sample naming convention is identified in the field sampling plan. The Field Quality Control (QC) Supervisor or other field-sampling leader shall ensure that the sample naming convention is implemented. The laboratory coordinator, CTO Manager, and/or other designated personnel shall ensure on a daily basis that unique, appropriate COC sample numbers and sample identifiers have been assigned. The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The prime contractor Technical Director will designate one person in each office (e.g., the laboratory coordinator) to track site designations used in the COC sample number.

5. Procedures

A COC sample number and sample identifier shall be assigned as described below. It is critical that each sample name have a unique COC sample number and sample identifier; otherwise, data cannot be properly stored and tracked in the database.

5.1 COC SAMPLE NUMBER

Use the following format for the COC sample number:

abccc

Where:

a = A letter indicating the office managing the CTO
b = A letter indicating the project or site, for example
    A = first site
    B = second site
    C = third site, etc.
ccc = Chronological number, for example
    001 = first sample from the site
    002 = second sample from the site
    105 = 105th sample from the site
    Field QC samples should be included in this chronological sequence

For example, the 23rd sample from the Carpentry Shop Dip Tank site (assigned project “A” for b above; the office will be assigned “D”) being investigated would be referred to as “DA023.” This might be a soil sample, water sample, trip blank, equipment blank, field duplicate, or other sample type. Using this COC sample number, the samples will be submitted to the laboratory “blind,” that is, the laboratory should not know whether each sample received is a site or field QC sample.

If a sample is lost during shipping, the replacement sample must be assigned a new COC sample number. If different containers for the same sample are shipped on different days, a new COC sample number must be assigned.

When numbering reaches the letter Z, the 26th site, it may begin with a new first letter “a,” which must be coordinated with the prime contractor QA Manager or Technical Director and Coordinator or designee to ensure that it has not been used by another CTO.

Alternatively, the “ab” designators can serve to identify a unique project field, such as “RH” for the Red Hill site.

5.2 SAMPLE IDENTIFICATION NUMBER

The following format is provided as a suggested guidance. Individual site objectives may necessitate variations to the suggested guidance. Coordinate with the prime contractor QA Manager or Technical Director when considering deviating from this guidance.

AA-bbcc-dee-Dff.f

Where:

AA = Designates the site identification

bb = Sample type and matrix (see Table I-A-8-1)

cc = Location number (e.g., 01, 02, 03)

d = Field QC sample type (see Table I-A-8-2)

ee = Chronological sample number from a particular sampling location (e.g., 01, 02, 03)

D = The letter “D” denoting depth

ff.f = Depth of sample in feet bgs (to the measured decimal place). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

For example, the first subsurface soil sample collected from the Foundry Building (FB) borehole location four at a depth of 10 feet would be designated “FB-BS04-S01-D10.0.” These characters will establish a unique sample identifier that can be used when evaluating data.

Table I-A-8-1 presents the character identifiers to be used in the sample and matrix portion of the sample identification number. In all cases, the second letter indicates the sample matrix. Note grab, composite, and undisturbed sample designations in the field logbook.

Table I-A-8-1: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
SS	Surface Soil	Soil
IS	Surface Soil (ISM)	Soil
IB	Subsurface Soil (ISM)	Soil
BS	Subsurface Soil	Soil
BG	Subsurface Soil (Geotechnical)	Soil
SD	Sediment	Sediment
GW	Groundwater	Water
SW	Surface Water	Water
FP	Free Product	Oil
WQ	Water Blanks	Water
SG	Soil Gas	Soil gas
CC	Concrete Chips	Concrete

Identifier	Sample Type	Matrix
WS	Waste (IDW)	Soil
WW	Waste (IDW)	Water

IDW investigation-derived waste
ISM incremental sampling methodology

Table I-A-8-2 describes the field QC designator types. These field QC designators clarify the type of sample collected.

Table I-A-8-2: Field QC Sample Type Identifiers

Identifier	QC Sample Type	Description
S	Normal (Primary) Sample	All non-field QC samples
D	Duplicate	Collocate (adjacent liners)
R	Triplicate	Replicate
E	Equipment Rinsate	Water
B	Field Blank	Water
T	Trip Blank	Analytical-laboratory-prepared sample -Water
M	Trip Blank	Analytical-laboratory-prepared sample – Methanol
L	Batch Test Sample	Batch Test Leaching Model Sample
P	Blind Spike	Performance testing sample

6. Records

Sample identifiers (and COC sample numbers, if appropriate) shall be identified in advance if the exact numbers of samples to be collected are known; these numbers may be listed on a spreadsheet along with requested analyses to be used as a reference by field sampling personnel.

The COC/analytical request form must be used to track all sample names. Copies of each COC form shall be sent daily to the CTO Laboratory Coordinator and with the samples to the analytical laboratory. An example of a COC form is included as Attachment III-E-2 of Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

In the field, personnel shall record in the field logbook the COC sample number of each sample collected, as well as additional information, such as the sampling, date, time, and pertinent comments.

7. Health and Safety

Not applicable.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

None.

Soil Sampling

1. Purpose

This section sets forth the standard operating procedure for soil sampling (surface samples, trench samples, and boring samples) to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil sampling procedures are followed during projects conducted under the NAVFAC Pacific ER Program, and that they are conducted or supervised by a qualified individual. A qualified individual for subsurface sampling is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience in the supervision of soil boring construction. A qualified individual for trenching, excavation (e.g., pit), or surface sampling supervision is one who has sufficient training and experience to accomplish the objectives of the sampling program. The CTO Manager shall also ensure that a qualified person, as defined in Procedure I-E, *Soil and Rock Classification,* conducts soil classification during all types of soil sampling. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 CONSIDERATIONS FOR MUNITIONS AND EXPLOSIVES OF CONCERN

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission (ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 SUBSURFACE SOIL SAMPLING

The purpose of subsurface soil sampling is to acquire accurate, representative information about subsurface materials penetrated during drilling or trenching. This is accomplished by logging lithologic information, classifying lithologic materials, and collecting lithologic samples for analysis using geotechnical or chemical methods.

5.2.1 Inspection of Equipment

The collection of reliable samples of subsurface materials depends partly on the types of samples that can be collected when using various subsurface exploration techniques. These procedures are described in Section 5.2. In all cases, the equipment shall be inspected prior to commencement of drilling for signs of fluid leakage, which could introduce contaminants into the soil. If, at any time during subsurface exploration, fluid is observed leaking from the rig, operations shall cease and the leak shall be immediately repaired or contained. All soil and other materials affected by the leak will be collected, containerized, and labeled for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

5.2.2 Preparation of Site

Proper preparation of the site prior to the commencement of subsurface exploration is essential for smooth drilling operations. It is required to protect the health and safety of site personnel. First, the site shall be inspected to ensure that there are no overhead hazards that could affect subsurface exploration. Then, all subsurface sampling locations shall be assessed using geophysical methods to identify subsurface utilities or hazards. If possible, the area shall be excavated by hand to a depth of 2 to 3 feet before beginning drilling. If surface or shallow samples are required, it is suggested that the hand excavation be done as close to the actual subsurface exploration as possible. The drill rig must have a means to guard against employee contact with the auger (e.g., guard around the auger; barricade around the perimeter of the auger; electronic brake activated by a presence-sensing device). All members of the field crew shall know the location of the kill switch, which must be readily accessible, for the equipment.

The equipment shall be situated upwind or side-wind of the borehole. The area surrounding, and in the vicinity of, the borehole shall be covered with plastic, including the area where cuttings are placed into 55-gallon drums and the equipment decontamination area. The required exclusion zones shall be established by using plastic tape or cones to designate the various areas.

5.2.3 Equipment Decontamination

To avoid cross-contamination, all sampling equipment utilized for borehole drilling and soil sampling that may potentially come into contact with environmental samples shall be thoroughly decontaminated as described in Procedure I-F, *Equipment Decontamination*. All sampling tools shall be decontaminated between each sampling event and between each borehole or trench. At a minimum, all equipment shall be steam-cleaned or undergo the wash-and-rinse process. All wash-and-rinse water shall be collected, containerized, and labeled for proper disposal. Clean equipment (e.g., augers and samplers) shall be protected from contact with contaminated soils or other contaminated materials prior to sample collection. Equipment shall be kept on plastic or protected in another suitable fashion. After a borehole is completed, all augers and contaminated downhole equipment shall be stored on plastic sheeting.

5.2.4 Handling of Drill Cuttings

All soil cuttings from borehole drilling shall be placed into 55-gallon U.S. Department of Transportation (DOT)-approved drums or other appropriate containers, such as a roll-off bin. The containerized cuttings shall be stored in a centralized area pending sample analysis to determine their final disposition. The procedure on investigation-derived waste (IDW) (see Procedure I-A-6, *Investigation-Derived Waste Management*) details drum handling and labeling procedures.

5.3 SUBSURFACE SOIL SAMPLE COLLECTION METHODS

Table I-B-1-1 describes the characteristics of the sampling methods for the drilling techniques frequently used for soil borings and monitoring well installation, as described in Procedure I-C-1, *Monitoring Well Installation and Abandonment*. The split-spoon sampling method is the most commonly used soil sampling technique. However, in certain circumstances, other methods may have to be used to obtain optimal soil sampling results.

Sampling and handling procedures for samples submitted for volatile organic compound (VOC) analyses are provided in Attachment I-B-1-1. Considerations when using incremental sampling (IS) methods are provided in Attachment I-B-1-1.

Table I-B-1-1: Characteristics of Common Subsurface Formation-Sampling Methods

Type of Formation	Sample Collection Method	Sample Quality	Potential for Continuous Sample Collection?	Samples Suitable for Analytical Testing?	Discrete Zones Identifiable?
Unconsolidated	Bulk Sampling (Cuttings)	Poor	No	No	No
	Thin Wall	Good	Yes	Yes	Yes
	Split Spoon	Good	Yes	Yes	Yes
	Trench	Good	No	Yes	Yes
	Core Barrels	Good	Yes	Yes	Yes
Consolidated	Cuttings (direct rotary)	Poor	No	No	No
	Core Barrels	Good	Yes	Yes	Yes

The following text describes the primary soil sampling methods used for the NAVFAC Pacific ER Program.

5.3.1 Split-Spoon Samples

Split-spoon sampling is usually used in conjunction with the hollow-stem or solid-stem auger drilling method and can be used for sampling most unconsolidated and semi-consolidated sediments. It is used less frequently for air and mud rotary, and casing drive methods. It cannot normally be used to sample bedrock, such as basalt, limestone, or granite. The method can be used for highly unconsolidated sands and gravels if a stainless-steel sand catcher is placed in the lower end of the sampler.

The split-spoon sampler consists of a hardened metal barrel, 2 to 3 inches in diameter (2 to 2.5 inches inner diameter) with a threaded, removable fitting on the top end for connection to the drill rods and a threaded, removable "shoe" on the lower end that is used to penetrate the formation. The barrel can be split along its length to allow removal of the sample.

The following steps are required to obtain a representative soil sample using a split-spoon sampler:

- Advance the borehole by augering until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Equip the sampler with interior liners that are composed of materials compatible with the suspected contaminants if samples are to be retained for laboratory analytical analysis. Generally, these liners consist of brass or stainless steel and are slightly smaller than the inner diameter of the sampler. It is recommended to use stainless-steel liners rather than

brass if samples are to be analyzed for metals. Always evaluate the composition of the liners with respect to the types of contaminants that are suspected.

- Attach the properly decontaminated split-spoon sampler (equipped with liners) either to the drill rods or to a cable system and lower it to the bottom of the borehole through the augers.
- Drive the sampler into the formation by either a manual or automatic hammer (usually a 140-pound weight dropped through a 30-inch interval). Record the number of blows required to drive the sampler at 6-inch intervals in the boring log since blow counts provide an indication of the density/compaction of the soils being sampled. The field geologist, hydrogeologist, or geotechnical engineer shall carefully observe the internal measuring technique of the driller and keep track of sampling materials to ensure the accurate location of samples. Continuous samples can be collected with the split-spoon method by augering or drilling to the bottom of the previously sampled interval and repeating the operation. Whether continuous or intermittent, this collection method disturbs samples and cannot be used for certain geotechnical tests that require undisturbed samples.
- Bring the split-spoon sampler to ground surface and remove it from the drill rods or cable system following sample acquisition. Loosen the upper and lower fittings and take the sampler to the sample handling area. At the sample handling area, remove the fittings, split the barrel of the sampler, and remove one side of the sampler. At this time, it is important to observe and record the percentage of sample recovery.

Liners—Sampler liners can be used to collect and store samples for shipment to laboratories, for field index testing of samples, and for removing samples from solid barrel type samplers. Liners are available in plastic, Teflon, brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 inches (152.4 millimeters) to 5.0 feet (1.53 meters). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short-term as samples are subsampled and preserved immediately on site. Teflon may be required for mixed wastes and for long-term storage. Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners with less tolerance may be required and a shortened sample interval used to reduce friction in the liner. Metal liners can be reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use (ASTM 2005).

Immediately remove the liners containing the soil samples from the sampler. Generally, the lowermost liner is considered the least disturbed and shall be retained as the analytical laboratory sample. However, in certain circumstances (such as with the use of a sand catcher), other liners may be more appropriate for retention as the laboratory sample. If liners containing the sample material are to be submitted to the laboratory, then cover the ends of the sample liner to be retained as the analytical laboratory sample with Teflon film and sealed with plastic caps. While currently not preferred by the State of Hawaii, if liners are submitted, the laboratories should be instructed to prepare the soil from the liner as an incremental sample to prevent biasing the results that can occur when discretely collecting the analytical volume. The site geologist, hydrogeologist, or geotechnical engineer shall observe the ends of the liner destined for analytical sampling and describe the physical nature of the sample (e.g., soil or rock type, grain size, color, moisture, as indicated in Procedure I-E, *Soil and Rock Classification*.) Then label the sample according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately place it on ice in a cooler as described in Procedure III-F, *Sample Handling, Storage, and Shipping*.

- Collect split-spoon soil samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.
- Collect split-spoon soil samples submitted for non-VOC analysis using the IS procedure found in Attachment I-B-1-1
- Any remaining liners collected from the sample can then be used for other purposes, such as providing a duplicate sample for field quality control or material for lithologic logging. These samples can also be used for headspace analysis as described in Section 5.4.
- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1. In most instances, an additional liner full of material is available for this purpose. Check to ensure that all liners contain similar material. If an extra liner full of material is not available, then log by collecting the extra material present in the end of the sampler shoe. Make a comparison to the material visible at the end of the sample liner destined for laboratory analysis to ensure that the entire sample consists of similar material. If not, then describe the different material to the extent possible by relating it to similar material that was encountered previously.
- If VOCs are suspected to be present, screen the sample with an organic vapor monitor (OVM) or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

5.3.2 Thin-Wall Samples

The thin-wall or Shelby tube sampler is usually used in conjunction with the hollow-stem and solid-stem auger drilling methods and is most useful when sampling clay- and silt-rich sediments. It can also be used with air and mud rotary and casing drive drilling techniques. It is amenable only to lithologies that are relatively soft and, in some cases, is not capable of penetrating hard clays or compacted sands. In addition, samples of unconsolidated sands cannot normally be acquired because they cannot be retained within the sampler, although a sand catcher can be utilized, in some cases, with moderate success.

The thin-wall sampler often consists of a single thin tube that is 3 to 4 inches in outer diameter and 1 to 3 feet in length. The upper end of the sampler has a solid metal section with a fitting for drill rods. There is no fitting for the lower end of the sampler, and it is usually open to allow sample acquisition; however, when sampling in poorly consolidated materials, a sand catcher may be placed in the lower end to ensure retention of the sample.

The following steps are required to obtain a representative soil sample using a thin-wall sampler:

- Advance the borehole by augering or drilling until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Place the sampler on the end of the drill rods and lower it to the bottom of the borehole.
- Instead of driving the sampler, use the hydraulic apparatus associated with the kelly bar on the drilling rig to press the sampler into the undisturbed formation. The thin-wall sampler may lack sufficient structural strength to penetrate the materials, in which case another sampling technique may be required. The samples obtained using this method cannot be used for certain geotechnical tests where undisturbed samples are required.
- Thin-wall samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.
- Following sample acquisition, bring the thin-wall sampler to the ground surface, remove it from the drill rods, and take it to the sample handling area.
- Immediately cover the ends of the sample with Teflon film and sealed with plastic caps if the sample is to be retained as a laboratory sample. Then label the sample according to Procedure III-E*, Record Keeping Sample Labeling, and Chain of Custody* and immediately place it on ice in a cooler. Extrude the sample from the sampler and inspect it if the sample is to be used only for lithologic logging.
- Conduct lithologic logging of each sample in accordance with Procedure I-E*, Soil and Rock Classification* and enter each sample into the boring log presented in Figure I-B-1-1. If the sample is contained in a sleeve, observe the ends of the sample in the sleeve to assess lithologic and stratigraphic characteristics.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination.*

5.3.3 Cores

A core barrel is often used to obtain core samples from harder lithologic materials, such as basalt, granite, and limestone, in instances where undisturbed samples are required for geotechnical testing, and in cases where completely continuous sampling is required. Complete recovery of samples during coring is often difficult when sampling unconsolidated and semi-consolidated lithologies, such as clays, silts, and sands.

Field Log of Boring

BORING NUMBER

SHEET ____ OF _____

PROJECT NAME	PROJECT NUMBER	ELEVATION AND DATUM	LOCATION
DRILLING COMPANY	DRILLER	DATE AND TIME STARTED	DATE AND TIME COMPLETED
DRILLING EQUIPMENT	DRILLING METHOD	COMPLETION DEPTH	TOTAL NO. OF SAMPLES
SIZE AND TYPE OF BIT	HOLE DIAMETER	NO. OF SAMPLES BULK SS	DRIVE PITCHER
DRILLING FLUID	DRILLING ANGLE	WATER LEVEL FIRST	AFTER _______ HOURS
SAMPLE HAMMER TYPE DRIVING WT. DROP		HYDROGEOLOGIST/DATE	CHECKED BY/DATE

LITHOLOGY	DEPTH (FEET)	SAMPLES	RECOVERY	BLOW COUNT	DESCRIPTION	USCS SYMBOL	ESTIMATED PERCENT OF			COMMENTS
							GR	SA	FI	

Figure I-B-1-1: Field Log of Boring

ASTM International (ASTM) has standardized rock coring methods (D-2113) (ASTM 2006). Several standardized core sizes for bits, shells, and casings have been established (e.g., RX, NX, SW). Table I-B-1-2 summarizes the various size standards for core barrels and bits.

Table I-B-1-2: Standard Core Barrel Sizes (in inches)

Description	RX or RW	EX or EW	AX or AW	BX or BW	NX or NW	HX or HW	PX or PW	SX or SW	UX or UW	ZX or ZW
Bit Set Normal I.D.	0.750	0.845	1.185	1.655	2.155	3.000	—	—	—	—
Bit Set Normal and Thin-wall O.D.	1.160	1.470	1.875	2.345	2.965	3.890	—	—	—	—
Bit Set Thin-wall. I.D	0.735	0.905	1.281	1.750	2.313	3.187	—	—	—	—
Shell Set Normal and Thin-wall O.D.	1.175	1.485	1.890	2.360	2.980	3.907	—	—	—	—
Casing Bit Set I.D.	1.000	1.405	1.780	2.215	2.840	3.777	4.632	5.632	6.755	7.755
Casing Bit Set and Shoe O.D.	1.485	1.875	2.345	2.965	3.615	4.625	5.650	6.780	7.800	8.810

I.D.	Inner Diameter
O.D.	Outer Diameter

The selection of the most practical core barrel for the anticipated bedrock conditions is important. The selection of the correct drill bit is also essential to good recovery and drilling production. Although the final responsibility of bit selection usually rests with the drilling contractor, there is a tendency in the trade to use “whatever happens to be at hand.” The selection of the diamond size, bit crown contour, and number of water ports depends upon the characteristics of the rock mass. The use of an incorrect bit can be detrimental to the overall core recovery. Generally, fewer and larger diamonds are used to core soft formations, and more numerous, smaller diamonds, which are mounted on the more commonly used semi-round bit crowns, are used in hard formations. Special impregnated diamond core bits have been developed recently for use in severely weathered and fractured formations where bit abrasion can be very high.

Core barrels are manufactured in three basic types: single tube, double tube, and triple tube. These basic units all operate on the same principle of pumping drilling fluid through the drill rods and core barrel. This is done to cool the diamond bit during drilling and to carry the borehole cuttings to the surface. A variety of coring bits, core retainers, and liners are used in various combinations to maximize the recovery and penetration rate of the selected core barrel.

The simplest type of rotary core barrel is the single tube, which consists of a case hardened, hollow steel tube with a diamond drilling bit attached at the bottom. The diamond bit cuts an annular groove, or kerf, in the formation to allow passage of the drilling fluid and cuttings up the outside of the core barrel. The single tube core barrel cannot be employed in formations that are subject to erosion, slaking, or excessive swelling, as the drilling fluid passes over the recovered sample during drilling.

The most popular and widely used rotary core barrel is the double tube, which is basically a single tube barrel with a separate and additional inner liner that is available in either a rigid or swivel type of construction. In the rigid types, the inner liner is fixed to the outer core barrel so that it rotates with the outer tube. In contrast, the swivel type of inner liner is supported on a ball-bearing carrier, which allows the inner tube to remain stationary, or nearly so, during rotation of the outer barrel. The sample, or core, is cut by rotation of the diamond bit. The bit is in constant contact with the drilling fluid as it flushes out the borehole cuttings. The addition of bottom discharge bits and fluid control valves to the core barrel system minimizes the amount of drilling fluid and its contact with the sample, which further decreases sample disturbance.

The third and most recent advancement in rotary core barrel design is the triple tube core barrel, which adds another separate, non-rotating liner to the double tube core barrel. This liner, which retains the sample, consists of a clear plastic solid tube or a split, thin metal liner. Each type of liner has its distinct advantages and disadvantages; however, they are both capable of obtaining increased sample recovery in poor quality rock or semi-cemented soils, with the additional advantage of minimizing sample handling and disturbance during removal from the core barrel.

The rotary core barrels that are available range from 1 to 10 inches in diameter, and the majority may be used with water, drilling mud, or air for recovering soil samples. Of the three basic types of core barrels, the double tube core barrel is most frequently used in rock core sampling for geotechnical engineering applications. The triple tube core barrel is used in zones of highly variable hardness and consistency. The single tube is rarely used because of its sample recovery and disturbance problems.

Coring to obtain analytical samples requires only filtered air as the drilling fluid. The core barrel operates by rotating the outer barrel to allow the bit to penetrate the formation. The sample is retained in the inner liner, which in most samplers does not rotate with the outer barrel. As the outer barrel is advanced, the sample rises in the inner liner. In general, a secondary liner consisting of plastic or metal is present within the inner liner to ensure the integrity of acquired samples.

Obtain soil or rock core samples with a core barrel or a 5-foot split-spoon core barrel using the following procedure:

- Drill the core barrel to the appropriate sampling depth. It is important to use only clean, filtered air (i.e., particulate- and petroleum-free) as drilling fluid while coring to obtain samples for laboratory analysis. If necessary, distilled water may be added through the delivery system of the coring device by the driller, provided that the drilling returns cannot be brought to the surface by air alone.
- Retrieve the core barrel from the hole. Use care to ensure that the contents of the core barrel do not fall out of the bottom during withdrawal and handling.
- Open the core barrel by removing both the top and bottom fittings. Then remove the sample within the inner liner from the core barrel and take it to the sample handling area.

- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.

Collect core samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.

- If rock core samples are to be recovered for analytical laboratory or geotechnical analyses, the core barrel will either be lined with a sample container (e.g. stainless steel or acrylic liner), or the samples will be transferred to an appropriate sample container (e.g. stainless steel / acrylic liner, glass jar). Samples collected or placed in stainless steel or acrylic liners shall have the ends of the liners covered with Teflon film and sealed with plastic end caps. The sample containers shall be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and Procedure III-F, *Sample Handling, Storage, and Shipping*, and immediately placed on ice in a cooler.
- Place the samples in core boxes if samples are to be catalogued and stored. Affix the CTO number; site name; borehole number; start depth; end depth; date; and name of the geologist, hydrogeologist, or geotechnical engineer to the core box. Store the samples in a clean, dry area on site during the duration of field sampling; samples shall not be brought back to the office or equipment storage area. Document proper disposal at the completion of field sampling.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

5.3.4 Bulk Samples

The term “bulk sample” represents a sample collected from borehole cuttings either from the hollow-stem auger flights or the discharge of any of the rotary or cable tool drilling techniques. This type of sample is useful for describing soils or consolidated materials, where no undisturbed samples representative of a specific depth are being collected. It should be noted that this type of sample is generally considered to be the least acceptable of the types of samples previously described in this section and shall be used only when detailed lithologic data are not needed.

Handling and lithologic logging of bulk samples should be performed in a manner consistent with that used for split-spoon samples. An estimate of the depth (or range of depths) from which the sample was obtained, and date and time of collection should be recorded on the boring log. Samples are usually collected every 5 feet, preferably at several different times during a 5-foot drilling run so that lithologic variations occurring over the drilling interval can be noted. Rock fragments commonly range in size from 1/16 to 1/2 inch, with many fragments larger than 1/4 inch. Larger fragments can often be obtained with reverse circulation rotary drilling. Rotary-tool samples usually contain some caved materials from above and, when drilling with mud or water rotary, the cuttings may contain soil and rock recirculated by the mud/water pump; therefore, care must be exercised when interpreting lithologic logs completed using data from this type of sample.

Because the collection of samples at the surface lags behind the actual drilling of a given lithologic bed at depth, the samples usually represent a depth less than that of the current depth of the drill bit. The amount of lag may be significant in deeper boreholes, but can be eliminated by collecting samples after circulating for a period of time sufficient to permit the most recently drilled materials to reach the surface.

5.3.5 Borehole Abandonment

Following completion of soil sampling, the borehole shall be properly abandoned unless a monitoring well is to be installed. Abandonment shall occur immediately following acquisition of the final sample in the boring and shall consist of the placement of a bentonite-cement grout from the bottom of the boring to within 2 feet of ground surface. The grout mixture shall consist of a mix of 7 to 9 gallons of water per 94-pound bag of Portland Type I or II cement with 3 to 5 percent by weight of powdered bentonite. Other commercial products such as Volclay are also acceptable with approval of the CTO Manager and QA Manager or Technical Director. The bentonite-cement grout shall be placed in one continuous pour from the bottom of the boring to within at least 0.5 foot to 2 feet of ground surface through a tremie pipe or hollow-stem augers. Additional grout may need to be placed if significant settlement occurs. The remaining portion of the boring can be filled with topsoil.

5.3.6 Trenching and Pit Sampling

Trenching is used in situations where the depth of investigation generally does not exceed 10 to 15 feet and is most suitable for assessing surface and near-surface contamination and geologic characteristics. In addition, trenching allows detailed observation of shallow subsurface features and exposes a wider area of the subsurface than is exposed in borings. Pit sampling is typically conducted in conjunction with a removal or remedial action.

A backhoe is usually used to excavate shallow trenches to a depth of no greater than 15 feet. Front-end loaders or bulldozers are used when it is not possible to use a backhoe; for example, when materials lack cohesion or are too stiff, or the terrain is too steep for a backhoe. Larger excavations (i.e., pits) may require additional equipment as described in the CTO work plan (WP) or equivalent document.

Typically, trenches have widths of one to two backhoe buckets and range in length from 5 to 20 feet, although larger trenches can be dug depending on the objectives of the study. Pits will vary in size depending upon the scope of the removal/remedial action. Soils removed from the trench/pit shall be carefully placed on plastic sheeting or other appropriate materials in the order of removal from the trench or excavation. The shallow excavated materials can be placed on one side of the trench/excavation and deeper materials on the other side to allow better segregation of shallow and deep materials.

Soil sampling locations within each trench or pit shall be chosen on the basis of visual inspection and any VOC screening results. Samples shall be collected from either the sidewalls or the bottom of the trenches/excavations. Soil sampling should be conducted outside the trench/excavation, and personnel generally should not enter a trench or pit if there is any other means (e.g., backhoe buckets, hand augers, shovels, or equivalent) to perform the work. If entry is unavoidable, then a competent person shall first determine acceptable entry conditions including sloping, shoring, and air monitoring requirements, personal protective equipment (PPE), and inspections. In addition, the site-specific health and safety plan must be amended to include applicable requirements of 29 Code of Federal Regulations (CFR) 1910.146.

Equipment used for trench/pit sampling may include hand augers, core samplers (slide hammer), liners inserted manually into the soil, or hand trowels. In addition, samples may be obtained directly from the trench or from the backhoe bucket. All samples shall be properly sealed and labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. Sample locations and descriptions shall be described and recorded on the field trench/pit log.

Trench or pit samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.

The exposed materials shall be observed for lithologic and contaminant characteristics following completion of the excavation activities. Detailed mapping of the exposed walls of the trench shall be conducted, although in no instance shall personnel enter a trench without first determining acceptable entry conditions including sloping, shoring, and air monitoring requirements, PPE, and inspections as defined in 29 CFR 1910.146. A useful mapping technique for extremely long trenches or large pits is to examine the vertical profile of the excavation at horizontal intervals of 5 to 10 feet, in a manner similar to the method typically used for preparation of a geologic cross-section using soil borings. Field observations shall be noted in the field logbook and described in detail on a trench/pit log. An example of a field trench/pit log is presented in Figure I-B-1-2. The lithologic description shall include all soil classification information listed in Procedure I-E, *Soil and Rock Classification*. A cross-section of the trench or pit should also be included on the field trench/pit log. Photographs of the trench/pit are also an excellent way to document important subsurface features.

During backfilling of the excavation, the materials excavated from the greatest depth should be placed back into the excavation first. Lithologic materials should be replaced in 2- to 4-foot lifts and recompacted by tamping with the backhoe bucket. For certain land uses or site restoration, more appropriate compaction methods may be required. These methods shall be described in the CTO WP and design documents. The backfilled trench/pit shall be capped with the original surface soil. If materials are encountered that cannot be placed back in the excavation, they should be placed either in DOT-approved open-top drums or placed on and covered with visqueen or equivalent material and treated as IDW in accordance with Procedure I-A-6, *Investigation-Derived Waste Management.*

5.4 SURFACE SOIL SAMPLING

All surface soil samples shall be accurately located on field maps in accordance with Procedure I-I, *Land Surveying*. Detailed soil classification descriptions shall be completed in accordance with

Procedure I-E, *Soil and Rock Classification* and recorded on the surface and shallow soil sample log (Figure I-B-1-3).

In general, surface soil samples are not to be analyzed for VOCs unless there is sufficient evidence to suggest the presence of such compounds.

Methods commonly used for collection of surface soil samples are described below. Considerations when using IS methods are provided in Attachment I-B-1-1.

5.4.1 Hand Trowel

A stainless-steel or disposable hand trowel may be used for sampling surface soil in instances where samples are not to be analyzed for volatile organics. The hand trowel is initially used to remove the uppermost 2 inches of soil and is then used to acquire a representative sample of deeper materials to a depth of 6 inches. Generally, only samples within the upper 6 inches of soil should be sampled using these methods. The depth of the sample shall be recorded in the surface and shallow soil sample log (Figure I-B-1-3). The soil classification shall include all the information outlined in Procedure I-E, *Soil and Rock Classification*.

Soil samples collected using a hand trowel are usually placed into pre-cleaned, wide-mouth glass jars. The jar is then sealed with a tight-fitting cap, labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and placed on ice in a cooler in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping*. All sampling equipment must be decontaminated prior to each use according to the methods presented in Procedure I-F, *Equipment Decontamination*.

5.4.2 Hand Auger

A soil recovery hand auger consisting of a metal rod, handle, detachable stainless-steel core barrel, and inner sleeves can be used to obtain both surface soil and trench samples. Multiple extensions can be connected to the sampler to facilitate the collection of samples at depths up to 15 feet below the existing ground surface.

Pre-cleaned sample liners are loaded into the core barrel prior to sampling. In general, these liners are used not only to collect samples, but also to serve as the sample container. Alternatively, in instances where VOCs are not to be analyzed or where not enough samples can be collected to completely fill a liner, samples can be transferred to wide-mouth glass jars. In either case, the sample shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. To minimize possible cross-contamination, the soil recovery hand auger and sample liners shall be decontaminated prior to each use according to the procedures described in Procedure I-F, *Equipment Decontamination*.

5.4.3 Slide Hammer Sampling

In instances where the soil type precludes the collection of soil samples using the soil recovery hand auger, a manually operated slide hammer can be used to collect relatively undisturbed soil samples from excavations and surface soils. The slide hammer consists of a 6- to 12-inch core barrel that is connected to the slide hammer portion of the device using detachable extensions.

The core sampler is typically loaded with two to four sample liners, depending on the liner length, which are not only used to acquire the samples, but also serve as the sample container. Immediately following acquisition, samples shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*.

All of the sampling equipment that comes into contact with the sample medium shall be decontaminated in accordance with Procedure I-F, *Equipment Decontamination*. Split-barrel slide hammer core samplers, which have recently become available, are much easier to decontaminate than the older, single-piece core barrel, and should be used in place of the older core barrels where possible.

FIELD LOG OF TRENCH/PIT

Project Name							
Trench Number		Project Number	Elevation and Datum			Location	
Equipment Supplier		Operator	Date and Time Started			Date and Time Completed	
Equipment Type		Trench Orientation	Total Depth			Total Number of Samples	
Bucket Width	Trench Length	Trench Width	No. Of Samples	Bulk	Ss	Drive	Hand Auger
Geologist or Hydrogeologist/Date			Check by/Date				

SOIL DESCRIPTION

				Est. % of			
LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	G	S	F	COMMENTS
							Description taken _______ feet
							from ______ end of trench.

Figure I-B-1-2: Field Log of Trench/Pit

SURFACE AND SHALLOW SOIL SAMPLE LOG

Project Number	Project Name	Date	Time
Sample Identification Number and Time		Checked by	
Sampled by		Recorded by	
Method of Collection			
Surface Description			
Notes			

Soil Sample Data

Location	
Coordinates	Elevation

LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	Est. % of			COMMENTS
				G	S	F	

Figure I-B-1-3: Surface and Shallow Soil Sample Log

5.4.4 Hand Sampling Using Sample Liners

Surface soil samples can sometimes be collected by hand using just the sample liners. This method can be used in cases where the surface soils are soft or where it is advantageous to minimize the disturbance of the sample (such as when sampling for volatiles). Obtaining surface soil samples with this method consists merely of pushing or driving the sample tube into the ground by hand.

The sample liner (with the collected sample inside) is then removed from the ground and capped with Teflon film and plastic end caps. The sample is labeled according to Procedure III-E, *Record Keeping, Sampling Labeling, and Chain-Of-Custody* and immediately placed on ice in a cooler. All liners shall be decontaminated prior to use in accordance with Procedure I-F, *Equipment Decontamination*. Since the only pieces of equipment used are the sample liners, this method helps to minimize the required amount of equipment decontamination.

5.5 VOLATILE ORGANICS SCREENING AND HEADSPACE ANALYSIS

Volatile organics screening and headspace analysis is performed to preliminarily assess if the sample contains VOCs. Volatile organics screening and headspace analysis of samples shall be performed using a portable organic vapor analyzer (OVA), a portable photoionization detector (PID), or other similar instrument.

Volatile organics screening and headspace analysis is intended as a field screen for the presence of VOCs. The method measures the presence or absence of VOCs in the headspace (air) above a soil sample. Various factors affect the level of VOCs volatilizing from soils, such as concentration in the soil, temperature of the soil and air, organic carbon content of the soil, equilibration time, moisture content of the soil, and the chemical and physical characteristics of the VOCs. Therefore, headspace readings can only be regarded as qualitative assessments of volatiles, and caution should be exercised if using this technique to select samples for analytical testing. OVA and PID readings can vary because the two instruments have different sensitivities to the various VOCs and are usually calibrated relative to different gas standards (i.e., methane for the OVA and isobutylene for the PID).

In order to screen samples for VOCs, the instrument probe shall be inserted into the top of the sample liner immediately after the sampler is opened. The instrument response (normally in parts per million) is then recorded in the field notebook and/or the field log.

For headspace analysis, a portion of the sample is transferred into a zipper storage bag or pre-cleaned glass jar, which is then sealed and agitated. The VOCs are allowed to volatilize into the headspace and equilibrate for 15 to 30 minutes. Next, the instrument probe is then inserted into the container to sample the headspace, and the instrument response is recorded in the field notebook and/or the field log.

6. Records

Soil classification information collected during soil sampling should be documented in borehole, trench, and surface soil log forms. All log entries shall be made in indelible ink. Information concerning sampling activities shall be recorded on sample log forms or in the field logbook. The CTO Manager or designee shall review all field logs on at least a monthly basis. Procedures for these activities are contained in this manual. Copies of this information should be sent to the CTO Manager and to the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM D6282-98. West Conshohocken, PA.

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Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-E, *Soil and Rock Classification*.

Procedure I-F, *Equipment Decontamination.*

Procedure I-I, *Land Surveying.*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

Procedure III-F, *Sample Handling, Storage, and Shipping.*

9. Attachment

Attachment I-B-1-1: Sampling and Handling Procedure: Analysis of Soil for Volatile Organic Compounds

Attachment I-B-1-1

Sampling and Handling Procedure: Analysis of Soil for Volatile Organic Compounds

1. Laboratory Requirements

The laboratory must be capable of performing (1) United States (U.S.) Environmental Protection Agency (EPA) Solid Waste (SW)-846 Method 5035 and (2) Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives (EPA 2007). The laboratory must have method performance data to verify this capability.

Sampling and handling procedures for the analysis of soil for volatile organic compounds (VOCs) will depend on the project objectives and the sampling approach. The laboratory is responsible for providing the necessary sample containers with preservatives (if applicable) that meet consumable certification requirements. The following section describes the consumable options for VOC soil sampling. In addition, sample containers must have a sample label and be weighed prior to shipment to the field for use. The laboratory is responsible for recording the weight of each container before and after sampling. Alternately, EnCore-type samplers may be employed.

The laboratory must provide a minimum of three prepared containers, or EnCore-type samplers, for each soil sample analyzed for VOCs.

2. Supplies

- Disposable coring devices (hereafter referred to as coring devices): either vendor-calibrated sample coring devices, or EnCore-type samplers. One coring device sampler per sampling location, plus additional coring devices (5 percent) in case of breakage.
- The number and type of laboratory prepared sample containers will depend upon the sampling scheme employed.
- For discrete soil VOCs, two 40 milliliter (mL) volatile organic analyte (VOA) vials with 5 mL of ASTM International (ASTM) Type II water, single-use magnetic stir bar with Teflon lined septa cap, one VOA vial with 5 mLs of methanol with a Teflon lined septa cap, and sample label, or three EnCore-type samplers.
- For incremental soil VOC samples, the total number of sample containers will depend upon the number of increments collected. The laboratory shall provide containers which contain a maximum of 30 mL of methanol (or as dictated by Federal Laws for transporting Exempted Limited Quantities of Dangerous Goods (49 CFR 100-185) with a Teflon lined septa cap, and sample label.
- Reagent/trip blanks: laboratory-prepared in identical fashion to sample vials.
- Temperature blanks: laboratory-prepared.
- 2-ounce glass jars with Teflon-lined lid: for dilution purposes and percent moisture determination.
- Nitrile or equivalent gloves.

3. Field Sampling

The following directions apply to all sampling techniques for soil coring devices: For reasons stated in section 3.4of this attachment and explained in detail in Sections 8.2.1.8 and A7.2 of EPA Method 5035, core-type (i.e., Terra Core, EnCore, etc.) samplers are recommended for sample collection, not sample collection and transport (EPA 2007).

- Always wear clean gloves while handling sample containers to help prevent soil and other debris from adding to the weight of the vial. Always don a new pair of gloves and use a new core sampler for each sampling location.
- Whenever possible, collect the soil samples for VOC analysis in place. If this is not possible, practical, or safe, collect the sample from a sample liner, or if absolutely necessary, from a backhoe bucket. Avoid having particles of soil adhering to the grooves of the screw cap or the container threads.
- Collect VOA samples as quickly as possible to avoid unnecessary VOC losses. EPA Region 9 recommends total exposure of the soil sample to ambient conditions should not exceed 10 seconds.
- Once the soil has been transferred to the sample container, screw the cap back on and mark the sample ID on the label with a ballpoint pen. Do not use a pen that has high solvent concentrations in the ink such as a Sharpie.
- Place the VOA vial inside a cooler containing either wet ice in sealed bags or gel ice.
- Collect the number of sample containers as describe in Section 2 of this standard operating procedure at each sampling location. The same core sampler may be used to prepare all containers. Duplicate samples require collecting additional sample containers. For percent moisture purposes, soil must also be collected in 2-ounce or greater glass jars with Teflon-lined lids at each sampling location. If other analyses are being conducted for the sampling location, then the percent moisture may be obtained from other sample containers. The 2-ounce jar will be completely filled with zero headspace. If other analyses are not being conducted at the sampling location, then an additional sample must be collected in another 2-ounce glass jar for percent moisture.
- When incrementally collecting samples from a liner for non-VOC analysis, a core sampler may be used to obtain equal incremental sample volumes. The liner will have been sliced open prior to incremental sample collection for access to the entire length of the sample.
- Depending on the 1) pre-selected volume to be collected per sample, 2) the sample/liner length available for incremental sampling, and 3) the size of the core tool, collect as many cores from the entire soil sample/liner section that will total to the required sample volume. For example, if 30 grams is the volume to be collected per sample location, the sample/liner length is 6 inches, and a 5 gram core tool is used, then 6 incremental samples, located throughout the sample length to provide adequate, representative coverage of the entire

6 inches of sample, would be collected (i.e., 6 incremental samples could be taken at equally spaced locations across the sample length, totaling 30 grams of sample).

- Collect one equipment blank per laboratory or vendor shipment of Terra Core, as described in Procedure III-B, *Field QC Samples (Water, Soil)*, unless the syringes are certified clean (e.g., certificate of analysis or equivalent documentation) by the vendor.
- Place samples in bubble wrap or other protective covering. Place custody seals on the covering. Custody seals or tape must not be placed directly on the sample vials, as this will interfere with the analytical instrumentation, final weight of the sample, and ultimate sample VOC concentration.

The following additional directions for VOC soil sample collection are taken from EPA SW-846 Method 5035A Appendix A7.0 (EPA 2002).

Collection of Samples for Analysis

After a fresh surface of the solid material is exposed to the atmosphere, the subsample collection process should be completed in the least amount of time to minimize the loss of VOCs due to volatilization. Removing a subsample from a material should be done with the least amount of disruption (disaggregation) as possible. Additionally, rough trimming of the sampling location’s surface layers should be considered if the material may have already lost VOCs (been exposed for more than a couple of minutes) or if it might be contaminated by other waste, different soil strata, or vegetation. Removal of surface layers can be accomplished by scraping the surface using a clean spatula, scoop, knife, or shovel (ASTM 2005, Hewitt et al. 1999).

Subsampling of Cohesive Granular but Uncemented Materials Using Devices Designed to Obtain a Sample Appropriate Analysis

Collect subsamples of the appropriate size for analysis using a metal or rigid plastic coring tool. For example, coring tools for the purpose of transferring a subsample can be made from disposable plastic syringes by cutting off the tapered front end and removing the rubber cap from the plunger or can be purchased as either plastic or stainless-steel coring devices. These smaller coring devices help to maintain the sample structure during collection and transfer to the VOA vials, as do their larger counterparts used to retrieve subsurface materials. When inserting a clean coring tool into a fresh surface for sample collection, air should not be trapped behind the sample. If air is trapped, it could either pass through the sampled material causing VOCs to be lost or push the sample prematurely from the coring tool.

The commercially available EasyDraw Syringe, Powerstop Handle, and Terra Core sampler coring devices are designed to prevent headspace air above the sample contents. For greater ease in pushing into the solid matrix, sharpen the front edge of these tools. The optimum diameter of the coring tool depends on the following:

- Size of the opening on the collection vial or bottle (tool should fit inside mouth)
- Dimensions of the original sample, particle size of the solid materials (e.g., gravel-size particles would require larger samplers)
- Volume of sample required for analysis

For example, when a 5-gram (g) subsample of soil is specified, only a single 3-cubic-centimeter (cm^3) volume of soil has to be collected (assuming the soil has density of 1.7 g/cm^3). Larger subsample masses or more subsample increments are preferred as the heterogeneity of the material increases. After an undisturbed sample has been obtained by pushing the barrel of the coring tool into a freshly exposed surface and then removing the filled corer, quickly wipe the exterior of the barrel with a clean disposable towel.

The next step varies depending on whether the coring device is used for sample storage and transfer or solely for transfer. If the coring tool is used as a storage container, cap the open end after ensuring that the sealing surfaces are cleaned. If the device is to be solely used for collection and not for storage, immediately extrude the sample into a VOA vial or bottle by gently pushing the plunger while tilting the VOA vial at an angle (to avoid splashing any deionized water or methanol). The volume of material collected should not cause excessive stress on the coring tool during intrusion into the material, or be so large that the sample easily falls apart during extrusion. Obtain and transfer samples rapidly (<10 seconds) to reduce volatilization losses. If the vial or bottle contains ASTM reagent Type II water, hold it at an angle when extruding the sample into the container to minimize splashing. Just before capping, visually inspect the lip and threads of the sample vessel, and remove any foreign debris with a clean towel, allowing an airtight seal to form.

Devices that Can Be Used for Subsampling a Cemented Material

The material requiring sampling may be so hard that even metal coring tools cannot penetrate it. Subsamples of such materials can be collected by fragmenting a larger portion of the material using a clean chisel to generate aggregate(s) of a size that can be placed into a VOA vial or bottle. When transferring the aggregate(s), precautions must be taken to prevent compromising the sealing surfaces and threads of the container. Losses of VOCs by using this procedure are dependent on the location of the contaminant relative to the surface of the material being sampled. Therefore, take caution in the interpretation of the data obtained from materials that fit this description. As a last resort, when this task cannot be performed on site, a large sample can be collected in a vapor-tight container and transported to the laboratory for subsampling. Collect, fragment, and add the sample to a container as quickly as possible.

Devices that Can Be Used for Subsampling a Non-cohesive Granular Material

As a last resort, gravel, or a mixture of gravel and fines that cannot be easily obtained or transferred using coring tools, can be quickly sampled using a stainless-steel spatula or scoop. If the collection vial or bottle contains ASTM reagent Type II water, transfer samples with minimal splashing and without the spatula or scoop contacting the liquid contents. For some solids, a wide-bottom funnel or similar channeling device may be necessary to facilitate transfer to the container and prevent compromising the sealing surfaces of the container. Take caution when interpreting the data obtained from materials that fit this description. Loss of VOCs is likely due to the nature of the sampling method and the non-cohesive nature of the material, which exposes more surface area to the atmosphere than other types of samples. During the sampling process, non-cohesive materials also allow coarser materials to separate from fines, which can skew the concentration data if the different particle sizes, which have different surface areas, are not properly represented in the sample.

Use of the EnCore Sampler (or Equivalent) for Sample Transport and Storage

The EnCore sampler is a sampling device that can be used as both a simultaneous coring tool for cohesive soils and a transport device to a support laboratory (field or off site). The EnCore sampler is intended to be a combined sampler-storage device for soils until a receiving laboratory can initiate either immediate VOC analysis, or preserve extruded soil aliquots for later VOC analysis. It is meant to be disposed of after use. The commercially available device is constructed of an inert composite polymer. It uses a coring/storage chamber to collect either a 5-gram or 25-gram sample of cohesive soils. It has a press-on cap with hermetically a vapor-tight seal and locking arm mechanism. It also has a vapor-tight plunger for the non-disruptive extrusion of the sample into an appropriate container for VOC analysis of soil.

An individual disposable EnCore sampler (or equivalent) is needed for each soil aliquot collected for vapor partitioning or ASTM reagent Type II water sample preparation. Upon soil sample collection, store the EnCore sampler is at 4 ±2 degrees centigrade (°C) until laboratory receipt within 48 hours. Upon laboratory receipt, soil aliquots are extruded to appropriate tared and prepared VOA vials.

Validation data have been provided to support use of the EnCore sampler for VOC concentrations in soil between 5 and 10 parts per million, for two sandy soils, with a 2-day holding time at 4 ±2°C. Preliminary data (Soroni et al. 2001) demonstrate an effective 2-day (48-hour) holding time at 4 ±2°C for three sandy soil types with VOC concentrations at 100 parts per billion (ppb) (benzene and toluene at 300 ppb), as well as an effective 1- or 2-week holding time at <-7°C (freezing temperature). Recent published work (EPA 2001) neither definitively supports nor shows the EnCore device to be ineffective for sample storage at these preservation temperatures. Soils stored in the EnCore device for 2 calendar days at 4 ± 2°C are subject to loss of benzene, toluene, ethylbenzene, and xylene (BTEX) compounds by biodegradation if the soil is an aerated, biologically active soil (e.g., garden soil) (Soroni et al. 1999), but this BTEX loss is eliminated for up to 48 hours under freezing conditions (Hewitt 1999).

Further details on the EnCore sampler can be found in ASTM D4547-09 (ASTM 2009) or other publications.

Since Naval Facilities Engineering Command, Pacific action levels for VOCs in soil are typically associated with EPA Region 9 preliminary remediation goals for residential exposure scenarios, it is recommended that if EnCore samplers are used, they be frozen on site prior to shipment to the laboratory or extruded into a 40-mL VOA vial before shipment.

4. Sample Shipping and Holding Times

Samples preserved with water may be shipped either at 4 ±2°C or frozen at –7°C. The primary difference between the two shipping temperatures is the allowable holding time of the sample between sample collection and sample analysis. Samples shipped at 4 ±2°C must either be received and analyzed by the laboratory within 48 hours of sample collection or be received by the laboratory within 48 hours, frozen upon receipt, and analyzed within 14 days of sample collection. Samples shipped at –7°C and received/maintained by the laboratory in a frozen state must be analyzed within 14 days of sample collection.

If soil samples are to be field frozen, place the frozen samples in a cooler containing fresh, frozen gel packs or an ice and rock salt mixture, and ship the cooler using an overnight carrier. Dry ice may be used as a refrigerant for sample shipment, but must be coordinated with the overnight carrier in advance. The sample vials and caps must never be placed in direct contact with the dry ice since cracking may occur.

Soil or sediment samples contained in methanol and 2-ounce glass jars may be shipped in standard coolers using conventional shipping protocols described in Procedure III-F, *Sample Handling, Storage, and Shipping*, if the sample appears to have a moisture content that might cause the sample to expand and the glass jar to break due to freezing. If soil samples contained in 2-ounce glass jars are shipped in this manner, then trip blanks must accompany them during shipment.

Reagent/trip blanks that contain the same volume of ASTM Type II water and sample label used in the sample VOA vials must be included in each shipment. The reagent/trip blanks will be packaged, shipped, and analyzed in the same manner as field samples. Reagent/trip blanks will be analyzed to evaluate cross-contamination during shipment and to identify potential reagent contamination issues.

5. Laboratory Receipt

Upon receipt by the analytical laboratory, the sample temperature must be measured and recorded. The laboratory should note whether the samples are frozen. The samples must be logged in and assigned an analysis date to ensure that samples are analyzed within the 14-day holding time.

Once the samples have been logged in, they are placed in a freezer at 0°C or colder until they are analyzed. Samples arriving in a non-frozen state (greater than 0°C) are to be frozen upon receipt or analyzed within 48 hours of sample collection. If the duration of sample shipment exceeds 48 hours, the non-frozen samples should be analyzed on the day of laboratory receipt.

The laboratory will prepare the samples for analysis as dictated by laboratory standard operating procedures and SW-846 Method 5035, and analyzed by Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives.

6. References

49 Code of Federal Regulations (CFR) 100-185. *Hazardous Materials and Oil Transportation*.

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Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-F, *Sample Handling, Storage, and Shipping.*

Geophysical Testing

1. Purpose

This section sets forth the standard operating procedure for acquiring surface geophysical data to facilitate the collection of geologic, hydrogeologic, and geotechnical data related to hazardous waste site characterization. This procedure is for use by personnel working on the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

This procedure has been developed to help personnel: (1) determine whether surface geophysics should be used at a site; (2) choose the most applicable methods for a particular objective; and (3) implement proper field procedures. The specific supporting information explaining how various geophysical techniques will be applied shall be defined in the project-specific work plan (WP).

3. Definitions

For a more complete set of terms and definitions, refer to R. E. Sheriff (1991).

3.1 COUPLING

Coupling is the interaction between systems, and includes the following:

- A device for fastening together, as the plugs for connecting electrical cables.
- Aspects, which affect energy transfer. Thus the “coupling of a geophone to the ground” involves the quality of the plant (how firmly the two are in contact) and also considerations of the geophone's weight and base area because the geophone-ground coupling system has natural resonances and introduces a filtering action.
- The type of mutual electrical relationship between two closely related circuits. As coupling would exclude dc voltages by employing a series capacitive element. Direct coupling may exclude higher frequency signals by using a capacitive element across the inputs or may allow all components to pass.

- Capacitive coupling may occur because of mutual capacitive impedance, as between the wires in induced polarization (IP) circuits (see Section 3.6) or between a wire and ground.
- Inductive coupling occurs because of mutual inductive impedance, such as between grounded IP transmitter and receiver circuits, especially at higher frequencies, greater distances, or lower earth resistivity. This may give rise to false IP anomalies. Also called electromagnetic (EM) coupling.
- Resistive coupling in IP surveying is due to leakage between wires, between a wire and ground, or through the resistance of the ground itself between two grounded circuits.

3.2 ELECTRICAL LOG

- A generic term that encompasses all electrical borehole logs (spontaneous potential [SP], normal, lateral, laterologs, induction, microresistivity logs).
- Also used for records of surface resistivity surveying; to compare electrical survey.
- Electrolog, a borehole log, which usually consists of SP and two or more resistivity logs, such as short and long normal and long lateral resistivity logs. Electrolog is a Dresser Atlas trade name.

3.3 ELECTRICAL SOUNDING

Electrical sounding is an IP, resistivity method, or electromagnetic method in which electrode or antenna spacing is increased to obtain information from successively greater depths at a given surface location. Electromagnetic sounding can also be done with a fixed spacing by varying the frequency (time-domain technique). Electrical sounding is intended to detect changes in resistivity of the earth with depth at this location (assuming horizontal layering).

Electrical Survey:

- Measurements at or near the earth’s surface of natural or induced electrical fields to map mineral concentrations or for geological or basement mapping. (See electrical profiling, electrical sounding, electromagnetic method, resistivity method, self-potential method, induced-polarization method, telluric method, and magnetotelluric method).
- Electrical logs run in a borehole.

3.4 ELECTROMAGNETIC METHODS

A method in which the magnetic or electrical fields associated with artificially generated subsurface currents are measured. In general, EM methods are those in which the electric and magnetic fields in the earth satisfy the diffusion equation (which ignores displacement currents) but not Laplace’s equation (which ignores induction effects) nor the wave equation (which includes displacement currents). One normally excludes methods that use microwave or higher frequencies (and that consequently have little effective penetration) and methods that use direct coupling or very low frequencies in which induction effects are not important (resistivity and IP methods). Some methods that employ natural energy as the source, such as Afmag, are usually classified as EM methods, whereas other methods using natural energy, such as the magnetotelluric method, are not.

3.5 GEOPHYSICS

- The study of the earth by quantitative physical methods, especially by seismic reflection and refraction, gravity, magnetic, electrical, and radiation methods.
- The application of physical principles to study the earth. Includes the branches of: (a) seismology (earthquakes and elastic waves); (b) geothermometry (heating of the earth, heat flow, and volcanology and hot springs); (c) hydrology (ground and surface water and sometimes including glaciology); (d) oceanography; (e) meteorology; (f) gravity and geodesy (the earth's gravitational field and the size and form of the earth); (g) atmospheric electricity and terrestrial magnetism (including ionosphere, Van Allen belts, telluric currents); (h) tectonophysics (geological processes in the earth); and (i) exploration and engineering geophysics. Geochronology (the dating of earth history) and geocosmogony (the origin of the earth). These are sometimes added to the foregoing list. Enthusiasts in particular branches are inclined to appropriate the word "geophysics" to their own branch exclusively, whether that branch be ionospheric studies or exploration for oil.
- Exploration geophysics is the use of seismic, gravity, magnetic, electrical, EM, etc., methods in the search for oil, gas, minerals, water, etc., for economic exploitation.

3.6 INDUCED POLARIZATION

- IP is an exploration method involving measurement of the slow decay of voltage in the ground following the cessation of an excitation current pulse (time-domain method) or low frequency (below 100 Hertz) variations of earth impedance (frequency-domain method). Also known as the overvoltage method. Refers particularly to electrode polarization (overvoltage) and membrane polarization of the earth. Also called induced potential, overvoltage, or interfacial polarization. Various electrode configurations are used.
- The production of a double layer of charge at mineral interfaces or of changes in such double layers as a result of applied electric or magnetic fluids.

3.7 LOW-VELOCITY LAYER

- Weathering; a near-surface belt of very low-velocity material.
- A layer of velocity lower than that of shallower refractors (i.e., blind zones).
- The B-layer in the upper mantle from 60 to 250 kilometers deep, where velocities are about 6 percent lower than in the outermost mantle.
- The region just inside the earth's core.

3.8 RESISTANCE

Resistance is the opposition to the flow of a direct current.

3.9 RESISTIVITY

Resistivity is the property of a material that resists the flow of electrical current. Also called specific resistance. The ratio of electric-field intensity to current density. The reciprocal of resistivity is conductivity. In nonisotropic material, the resistivity is a tensor.

3.10 RESISTIVITY LOGS

- Well logs that depend on electrical resistivity, normal, lateral, laterolog, and induction log. Most resistivity logs derive their readings from 10 to 100 cubic feet of material about the sonde. Microresistivity logs, however, derive their readings from a few cubic inches of material near the borehole wall.
- Records of surface resistivity methods.

3.11 RESISTIVITY METHOD

- Observation of electric fields caused by current introduced into the ground as a means for studying earth resistivity in geophysical exploration. The term is normally restricted to those methods in which a very low frequency or direct current is used to measure the apparent resistivity. Includes electrical profiling and electrical sounding. Various array types are used.
- Sometimes includes IP and EM survey methods also.

3.12 SEISMIC SURVEY

Seismic survey is a program for mapping geologic structure by creating seismic waves and observing the arrival time of the waves reflected from acoustic-impedance contrasts or refracted through high-velocity members. A reflection survey is usually implied unless refraction survey is specifically mentioned. The energy source for creating the waves is usually impulsive (i.e., energy is delivered to the earth for a very short period of time) although energy is introduced for considerable time with the Vibroseis method. The energy is detected by arrays of geophones or hydrophones connected to amplifiers, and the information is amplified and recorded for interpretation. The data often are processed to enhance the wanted information (signal) and displayed in record-section form. Signal is recognized as a coherent event, although noise often is coherent also. Events considered to be reflections from acoustic-impedance contrasts (reflectors) are used to locate the reflectors, it being assumed that their attitudes are that of the geologic structure. Events attributed to be head waves are used to locate the refractors of which they are characteristic, it being assumed that the attitudes of these refractors are those of the geologic structure. Velocity analysis is also done on reflection data where the offset varies.

3.13 SELF-POTENTIAL/SPONTANEOUS POTENTIAL

- The direct coupling or slowly varying natural ground voltage observed between nearby non-polarizing electrodes in field surveying. In many mineralized areas, this is caused by electrochemical reaction at an electrically conducting sulfide body.
- A well log of the difference between the potential of a movable electrode in the borehole and a fixed reference electrode at the surface. The SP results from electrochemical SP and electrokinetic potentials, which are present at the interface between permeable beds adjacent to shale. In impermeable shales, the SP is fairly constant at the shale base-line value. In permeable formations, the deflection depends on the contrast between the ion content of the formation water and the drilling fluid, the clay content, the bed thickness, invasion, and bed-boundary effects, etc. In thick, permeable, clean non-shale formations, the SP has the fairly constant sand line value, which will change if the salinity of the formation water changes. In sands containing disseminated clay (shale), the SP will not reach the sand line and a pseudostatic SP value will be recorded. The SP is positive with respect to the shale base line in sands filled with fluids fresher than the borehole fluid.

3.14 TELLURIC

Telluric means of the earth, and often refers specifically to telluric currents.

3.15 TELLURIC CURRENT

Telluric current is a natural electrical earth current of very low frequency that extends over large regions and may vary cyclically in that direction. Telluric currents are widespread, originating in variations of the earth's magnetic field.

4. Responsibilities

CTO Managers are responsible for determining whether surface geophysical methods should be used on a project and if so, which methods should be used. This information should be included in the project-specific WP. The objectives of the geophysical investigation shall be stated explicitly in the subcontract WP. Further, deliverables by the subcontractor shall be clearly identified in the WP so the prime contractor knows what to expect from the subcontractor. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for ensuring that the appropriate selected procedures are conducted according to the instructions in this manual and the project specific sampling plan. In many cases, subcontractors will conduct these procedures. In these situations, the FM is responsible for overseeing and directing the activities of the subcontractor. The need to establish site-specific quality control procedures is particularly important.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 METHOD SUMMARY

A wide variety of surface-based geophysical methods exist that may apply to contamination delineation, geologic, hydrogeologic, or other site characterization/investigation requirements. In general, geophysical exploration methods provide for a non-invasive mapping of subsurface features through the measurement of the physical properties of a subsurface. Typically, an active signal (e.g., acoustic or electrical) propagates into the earth and the interaction of the signal with the subsurface materials is measured at the surface. Interpretation of the data provides a map or image of the subsurface. For example, electrical conductivity of soil governs the propagation of an electrical signal through the subsurface. The geologic/hydrologic/waste characteristics are then inferred from an interpretation of the data or correlated with borehole data.

For a geophysical survey to be successful, the method of choice must be capable of resolving a particular physical characteristic that relates to the goals of the investigation. For example, if a zone of contaminated groundwater is being investigated by an electrical method, the electrical conductivity of the contaminated portion of the aquifer should be sufficiently different from the uncontaminated portion to allow for identification of the ‘plume’. If the target (i.e., the high-conductivity plume in this example) does not contrast sufficiently with the uncontaminated portion, then the geophysical survey will not be successful. Often, preliminary calculations or a trial survey can be performed to evaluate a particular method.

For purposes of this procedure, the geophysical methods discussed herein are classified as follows:

- *Seismic Methods:* These include seismic refraction and reflection methods and are typically applied to investigate depths to water or geologic structures (stratigraphic horizons or depth to bedrock).
- *Electrical Methods:* A wide variety of these exist including Direct Current (DC) Resistivity, Low-Frequency EM Induction (i.e., loop-loop methods), Very Low Frequency EM, Ground Penetrating Radar (GPR), Complex Resistivity/IP, metal detection equipment, and SP profiling. These respond to variations in the electrical properties of a site, specifically the electrical conductivity and (for GPR) the dielectric/permittivity constant. Applications include general geologic/hydrologic mapping, identification of solute ‘plumes,’ and the detection of conductive metallic debris/objects.
- *Potential Field Methods:* Some methods do not require an active signal source and instead measure naturally occurring potential fields of the earth. These include measurements of the earth’s magnetic or gravitational fields. Magnetic methods are often used to detect the response of the earth's magnetic field to metallic objects and can be very effective in locating buried metallic materials. Gravity methods respond to subtle density variations and are typically used to map the depth/thickness of alluvial basins or to detect cavities within consolidated sediments (e.g., Karst sinkholes).

While a number of geophysical methods may be applied at hazardous waste sites, the scope of this procedure is limited to the following commonly applied methods:

Seismic:	Refraction
Electrical:	DC Resistivity
	EM Induction (Loop-Loop)
	GPR
	Metal Detection
	IP
	SP Profiling
Potential Field:	Magnetics

Often, geophysical contractors specialize in a particular survey method. The following references may be useful to provide additional information:

Dobrin, M. B. and C. H. Savit. 1988. *Introduction to Geophysical Prospecting*. McGraw-Hill.

Journals: Geophysics (Society of Exploration Geophysics); Geophysical Exploration European Association of Exploration Geophysicists; occasionally - Groundwater, Groundwater Monitoring Review (National Water Well Association).

Sheriff, R. E. 1991. *Encyclopedic Dictionary of Exploration Geophysics*. Society of Exploration Geophysics.

Telford, W. M., L. P. Geldart, R. E. Sheriff, D.A. Keys. 1998. *Applied Geophysics*. Cambridge University Press.

5.2 METHOD LIMITATIONS/INTERFERENCES AND POTENTIAL PROBLEMS

Each of the geophysical methods discussed herein are typically designed and implemented on a site-specific basis. Exercise care to ensure that a particular method is applicable and that an identifiable target is likely to exist. A determination must be made that the exploration target can be resolved versus the background signal/site conditions and that cultural or other 'noise' problems will not interfere. 'Cultural Noise' is defined as near-surface or surficial features (e.g., power lines or traffic vibrations) that can potentially mask or overwhelm the signal produced by the subsurface target.

All of the survey methods require field instrumentation and electronics that might be impacted by extreme climactic variations. Check the equipment regularly (daily, at a minimum) to ensure internal calibration. Review the manufacturers' guidelines and specifications prior to field application.

5.2.1 Seismic Method Limitations and Potential Problems

5.2.1.1 REFRACTION SURVEYS

Care should be exercised in avoiding the following potential problems:

- Poorly emplaced geophones (e.g., in loose soil)
- Poor couplings of induced signal (e.g. strike plate) with ground
- Intermittent electrical shorts in geophone cable (never drag geophone cables)
- Wet geophone connections
- Vibration due to wind and traffic-induced noise
- Improper gain/filter settings
- Insufficient signal strength
- Topographic irregularities (an accurate topographic survey is often required prior to field operations)

5.2.2 Electrical Method Limitations and Potential Problems

5.2.2.1 DC RESISTIVITY

Measurement of electrical resistivity represents a bulk average of subsurface material resistivity. In some instances, the resistivity of the target material may not contrast sufficiently with 'background' material to be observed with this method, especially as the target material gets thinner and/or deeper. If highly conductive soil/rock are present at shallow depths, electrical current may not penetrate to depths beyond this layer. An electrical current always follows the path of least resistance.

Care should be exercised in avoiding the following potential problems:

- Poorly coupled electrodes (insufficient grounding)
- Unshielded wires causing intermittent shorts
- Background electrical noise, such as natural currents (SP or telluric effects)
- EM coupling with power lines, causing the introduction of induced electrical currents into the receiver wire
- Grounded fence lines and power lines interfering with the survey
- Inadequate signal power (increase current levels to produce sufficient signal to noise ratios)
- Very low resistivity layer at the surface preventing the electrical field from penetrating deeper layers
- Very high resistivity layer at the surface (e.g. dry sandy gravel) preventing the electrical field from penetrating the surface layer

5.2.2.2 EM METHOD

A variety of EM methods may be applied; however, in practice, the Geonics EM31-MK2 and EM34-3 Loop-Loop instruments are usually used in hazardous waste surveys. The EM methods are similar to DC methods in application and are sensitive to conductive materials, except for the basic distinction that they are not electrically grounded. Complications may arise in the EM method in developed sites because aboveground, metallic objects or electrical fields may interfere. Power lines, automobiles, train tracks, water tanks, and other objects may completely dominate data results and render the method useless.

5.2.2.3 GPR METHODS

GPR methods are seldom useful where highly conductive conditions or clay is present at shallow depths. The high-frequency signal propagates as a function of both electrical conductivity and dielectric constant (permittivity). The selection of transmission frequency is important because high frequencies are rapidly attenuated and the signal may not penetrate. Often, a choice of frequencies is available and it is suggested to perform site-specific field tests over known, observable targets to determine whether GPR is appropriate for use.

Care should be exercised in avoiding the following potential problems:

- Improperly adjusted/configured equipment (e.g., antenna gain, filter slopes or gain thresholds)
- Insufficient signal and/or poor transmission qualities of the materials found at a site (e.g. clay, saline water conditions)
- The influence of reflected signals outside of the immediate zone of investigation upon the radar record (e.g., fences, power poles, buildings)

5.2.2.4 METAL DETECTION

Metal objects that are not survey targets, including those worn or carried by the operator, might interfere with measurements.

5.2.3 Potential Field Method Limitations and Problems

5.2.3.1 MAGNETICS

The signal measured by a magnetometer varies with time and is subject to variations induced by solar storms. Care should be exercised in avoiding the following potential problems:

- Metal objects that are not survey targets, such as those worn or carried by the operator and surficial metallic objects, interfering with measurements
- Lack of base station control to measure background field fluctuations
- Failure to maintain a constant sensor height with respect to ground elevation

5.3 SURVEY DESIGN/PRE-FIELD PREPARATION

5.3.1 Survey Design

Prior to performing a field investigation, it is often possible to estimate the effectiveness of a surface geophysical survey by using data interpretation software relevant to the survey or by other calculation methods. A sensitivity analysis is usually performed to determine if a geophysical target possesses sufficient contrast with background conditions to be detected using surface geophysics. In some instances, available site data or prior geophysical investigations may be available to obtain estimates of the geophysical characteristics of the site.

5.3.2 Field Preparation

- Verify that the required geophysical equipment is pre-calibrated and operational.
- Establish grid locations or set up traverses for location of sampling stations.
- Survey the station locations and record them on a scaled site plan.
- Test and calibrate geophysical equipment.

5.4 FIELD PROCEDURES

The following procedures apply to geophysical surveys conducted at a hazardous waste site. Procedures may vary since equipment capabilities and methodologies are rapidly evolving. In general, survey field locations, accurately record them, and ensure that the equipment is functional and calibrated. Typically, a control or base station location will be established to check the equipment response over the duration of the field investigation. In addition, ensure a high signal to noise ratio can be maintained to obtain a geophysical response representative of the target/zone of interest.

5.4.1 Seismic Refraction Methods

Use seismic refraction techniques to determine the structure of a site based upon the travel time or velocity of seismic waves within layers. Interpretation of the travel time variation along a traverse of geophones can yield information regarding the thickness and depth of buried strata. Seismic methods are often used to determine depths to specific horizons of contrasting seismic velocities, such as bedrock, clay layers, or other lithologic contrasts, and the water table (under unconfined conditions).

Procedures

- Check the seismic signal and noise conditions on the instrument to verify the proper functioning of geophones and cables and to check the instrument settings.
- When the seismic field equipment does not produce hard copies of seismic records, immediately plot the arrival time selected from the electronic display on a time/distance graph in the field. Produce a hard copy of the data, and keep it in the record file. Problems with improper picks are often discovered by early inspection of these plots.
- Background or offsite data may be required for correlation to site conditions. Correlation of the seismic data with electrical method results, if obtained, or with borehole or outcrop data, may be a useful means of assigning thickness or seismic velocities.
- If possible, analyze boring logs or other data to determine if low velocity (inverse layers) or thin beds may be present that might not be detected otherwise.
- Run the seismic system at a known standard base station for periodic checks of instrument operation.
- Properly store the data in digital form for subsequent processing and data evaluation.

5.4.2 Electrical Methods

5.4.2.1 DC RESISTIVITY

The resistivity method provides a measurement of the bulk electrical resistivity of subsurface materials. Application of the method requires that a known electrical current be induced into the ground through a pair of surface electrodes. Measure the resulting potential field (voltage) between a second pair of surface electrodes. Evaluate the subsurface electrical properties based on the current, voltage, and electrode position (array configuration).

Given the length of the wire cables, their connections to the electrodes, and the coupling of the electrodes with the ground, there are a number of potential problems for obtaining reliable data (e.g., poor electrical contact, short and open circuits). These conditions can be minimized by careful observation of instrument readings and trends.

Procedures

- Calculate and plot apparent resistivities during field acquisition as a means of quality control. If vertical electrical sounding is performed, the data plots (curves) should be smooth, and discontinuous jumps in the data should not occur. Profiling data should also show a general trend in the data from one station to the next; however, abrupt changes may occur in both sounding and profiling data due to “noise” from near-surface inhomogeneities or electrode contact problems.
- The resistivity instrument can be calibrated using standard resistors or by using the internal calibration circuits often contained within the equipment. Calibration is particularly important if the data are to be compared to resistivity measurements from other instruments or other parameters, such as specific conductance of water samples.

5.4.2.2 EM METHODS

EM methods provide a means of measuring the electrical conductivity of subsurface soil, rock, and groundwater. Electrical conductivity (the inverse of electrical resistivity) is a function of the type of soil, porosity, permeability, and the conductivity of fluids in the pore spaces. The EM method can be used to map natural subsurface conditions and conductive contaminant plumes. Additionally, trench boundaries, buried conductive wastes, such as steel drums, metallic utility lines, and steel underground storage tanks, might potentially be located using EM techniques.

Following factory calibration, the instruments will normally retain their accuracy for long periods; however, the user should establish a secondary standard area at the field site for periodic recalibration. This will provide a reference base station to check “drift” in the instrument’s performance and to permit correlation between instruments.

While precision can be easily checked by comparing subsequent measurements with the instrument at a standard site, accuracy is much more difficult to establish and maintain.

EM instruments are often used to obtain relative measurements. For these applications, it is not critical to maintain absolute accuracy; however, the precision of the instrument can be important. For example, in the initial mapping of the spatial extent of a contaminant plume, a moderate level of precision is necessary. If the same site is to be resurveyed annually to detect small changes in plume migration and movement, a very high level of precision is necessary.

If the objective of the survey is to obtain quantitative results from the EM data for correlation to other measurable parameters (e.g., specific conditions), proper steps should be taken to ensure good instrument calibration. This is particularly important when performing surveys in areas of low conductivity, where measurement errors can be significant.

The dynamic range of EM instruments varies from 1 to 1,000 millimhos/meter (mmho/m). At the lower conductivities, near 1 mmho/m and less, it is difficult to induce sufficient current in the ground to produce a detectable response; hence, readings may become unreliable. At conductivity values greater than about 100 mmho/m, the received signal is no longer linearly proportional to subsurface conductivities, and corrections must be applied to the data, if it is to be used for quantitative purposes.

Procedures

- Maintain or verify calibration records from the equipment supplier or manufacturer. Calibrate the EM system regularly.
- Prior to conducting a survey, select a temporary site on location for daily calibration checks. Conduct calibration checks twice daily, before and after conducting daily survey operations. Readings shall repeat to +/-5 percent. Originals of all calibration records shall remain on site during field activities, and copies shall be submitted to the records file. The original calibration records shall be transferred to the project files upon completion of the fieldwork.

  Note: Conduct calibration checks outside the influence of power lines, buried utilities, buried metal objects, fences, etc. on a relatively flat surface.

- The field operating party shall check instrument stability when there is local or distant thunderstorm activity. EM radiation from thunderstorms can generate noise in the EM system. It may be necessary to postpone operations during rainstorms and resume them when they have passed.
- Exercise technical judgment such that conductivity readings recorded in the field are reasonable with respect to existing site conditions.
- Record instrument sensitivity settings in the field notebook as readings are taken. Submit the notebook to the records file.

5.4.2.3 GPR

GPR uses high frequency radio waves to acquire subsurface information. Energy is radiated downward into the subsurface through a small antenna, which is moved slowly across the surface of the ground. Energy is reflected back to the receiving antenna, where variations in the return signal are continuously recorded. This data produces a continuous cross sectional “picture” or profile of shallow subsurface conditions. These responses are caused by radar wave reflections from interfaces of materials having different electrical properties. Such reflections are often associated with natural hydrogeologic conditions, such as bedding, cementation, moisture content, clay content, voids, fractures, and intrusions, as well as manmade objects. The radar method has been used at numerous hazardous waste sites to evaluate natural soil and rock conditions, as well as to detect buried wastes and buried metallic objects.

The radar system measures two-way travel time from the transmitter antenna to a reflecting surface and back to the receiver antenna. Calibration of the radar system and data requires a two-step process:

- First, accurately determine the total time window (range) set by the operator.
- Second, determine the EM velocity (travel time) of the local soil-rock condition.

After completing these two steps, the radar data may then be calibrated for depths of particular features.

Calibrate the time window (range) that has been picked for the survey by using a pulse generator in the field. This generator is used to produce a series of time marks on the graphic display, measured in nanoseconds. These pulses are counted to determine the total time range of the radar. A calibration curve can be made up for each radar system.

In order to precisely relate travel time to actual depth units, determine the velocity (or two-way travel time per unit distance) for the particular soil or rock found at the site.

Various levels of accuracy in determining travel time can be used. These may range from first order estimates to precisely measured onsite values.

Using the depth of a known target (trenches, road cuts or buried pipes/road culverts can provide a radar target of known depth), a radar record taken over the known target, and a time scale provided by the pulse generator will provide basic calibration record. From these data, a two-way travel time can be accurately determined at the given target location. Because this approach may give accurate calibration at the specific site, it must be assumed that conditions in other areas to be surveyed are the same as in the calibration areas. If they are not, errors will occur in determining depths.

If significant changes in soil type or moisture content occur with depth, travel time will not be the same throughout the vertical radar profile, and the vertical radar depth scale may be non-linear. Such a condition is common, and occurs whenever an unsaturated zone exists over a saturated zone.

Procedures

- Check the time scale of the GPR unit regularly for accuracy. This can be done either on or off the site by placing the GPR unit at a known distance from the ground, a wall, etc., and measuring the two-way travel time to that reflecting surface in the air. The velocity of electromagnetic waves in air is 1 foot per nanosecond (3×10^8 meters per second). The following equation shall be used:

  $$t = 2d/c$$

  Where:

  t = two-way travel time from antenna to the surface (nanoseconds)

  d = distance of antenna to the surface (feet)

  c = velocity of light in air, (1 foot/nanosecond)

- Prior to conducting a survey, conduct a GPR traverse over a buried object of known depth (if available). From the two-way travel time and the measured burial depth of the object, the average electromagnetic wave velocity in soil can be calculated from the following equation:

  $$V = 2d/t$$

  The average dielectric constant of the soil is then calculated using:

  $$Er = c^2/v^2$$

  Where:

  Er = average relative dielectric constant of soil (unitless)

  c = velocity of light in air (1 foot/nanosecond)

  v = average electromagnetic wave velocity of the soil (feet/nanosecond)

  Note: The equation above assumes a soil with a relative magnetic permeability of 1. Exercise technical judgment such that soil velocity and relative dielectric constant values are reasonable with respect to existing site conditions.

- A short GPR traverse shall be repeated twice daily over a known feature prior to and after conducting daily operations. Exercise technical judgment to ensure that variations between repeat readings are due to changing soil conditions rather than the electronics.

5.4.2.4 METAL DETECTION - MAGNETOMETERS

Magnetometers are designed to provide measurements of the earth's magnetic field. In hazardous waste site investigations, magnetometers are invaluable for detecting buried drums and for delineating the boundaries of areas containing ferrous metallic debris.

Procedures

- Check the proposed date of the magnetic survey for solar flares to ensure that anticipated background conditions do not occlude data collection (Bureau of Standards, Boulder, CO, Goldendale, WA).
- Obtain a daily background reading in the immediate vicinity of the site to be surveyed. This reading should be outside the influence of all sources of cultural magnetic fields (e.g., power lines, pipeline). Exercise technical judgment such that the background reading is reasonable with regard to published data for the total magnetic field intensity at the site latitude and longitude. This daily background reading should repeat to within reasonable diurnal variations in the earth's magnetic field.
- Take sequential readings twice daily, before and after normal magnetic surveying operations. Take these readings (within 10 seconds of each other) at any location on site, distant from cultural magnetic fields, and record them in the field notebook. Two or three sequential readings should be sufficient. In the absence of magnetic storms (sudden and violent variations in the earth's magnetic field), the readings should compare within 0.1 to a few tenths of a gamma. Variations during magnetic storms may approach 1 gamma.
- Take base station readings so that the efforts of diurnal variation in the earth's magnetic field may be removed from the data. Magnetic storms can be detected if the base station sampling frequency is high enough. It may be necessary to postpone operations during magnetic storms and resume them when they have passed. Identification of such periods of rapid synoptic variation may be documented at a permanent base stations set up on site where continuous readings are automatically recorded every 10 to 15 minutes. Alternatively, readings may be manually recorded at base stations during the survey every 45 to 60 minutes.
- Use of automatic recording magnetometers requires recording the magnetometer readings for the first and last station of each traverse in a field notebook. At the end of the day, compare the data recorded in the field notebook with data from the automatic recording device. Data recorded in the field notebook should be within 1 gamma of the values derived from the recording device. It is recommended to transfer the data onto hard copies from the recording device on a daily basis.

Total field measurements may be corrected for these time variations by employing a reference base station magnetometer; changes in the earth's field are removed by subtracting fixed base station readings from the moving survey data. Gradiometers do not require the use of a base station, as they inherently eliminate time variation in the data.

5.4.2.5 SP PROFILING

This method is different from other electrical techniques in that no artificial current source is used to inject a signal into the ground; only the naturally occurring voltage potentials are measured between surface stakes. These natural voltages are produced by chemical oxidation reactions between groundwater and different soil and mineral types.

SP equipment consists of a digital, high-impedance volt meter; two porous pot electrodes; and cables. SP equipment should have a resolution of at least ±2 millivolts (mv) and accuracy within ±10 mv.

Procedures

- Calibrate equipment per the manufacturer's specifications. At a minimum, calibrate the equipment twice daily, once prior to beginning operations and once at the end of daily operations. Record calibration results in the field log.
- Each SP station shall be identified with a unique number and located on a site layout drawing. Record profiling results for each station using a field data form that includes the time of each measurement. Annotate the form to show any natural or cultural features near or between the SP stations.
- Establish a base station for the purpose of measuring instrument drift during the SP profiling activities. Take the instrument to the base station routinely during the day, and obtain readings from one location at the base station. Obtain base station readings at the beginning and end of each day and at interim intervals not exceeding 4 hours in duration.
- Reduce data by adjusting measurements obtained for instrument drift. Base station readings are plotted as a separate curve from profiling station measurements. The drift is interpolated (straight line) between base station readings as a function of time and the appropriate drift correction is subtracted from each profiling station measurement. Reduced data are used for interpretation.
- Interpret data by plotting reduced data (either for linear cross-sections of the study area or as surface contours over the study area surface). Anomalies are identified from these plots, and inferences regarding their sources are developed.

5.4.3 Post-Operations

Geophysical personnel working at a site should follow standard hazardous waste site protocols. In many cases, the geophysical survey may precede services that may result in personnel contact with hazardous waste/materials. Geophysical personnel at all sites should follow standard hazardous waste site decontamination procedures.

5.5 DATA REDUCTION/DATA INTERPRETATION

Geophysical surveys typically require significant data reduction and processing. The exact methodology depends upon the purpose, scope, and type of survey.

Data interpretation and presentation reports should include the following:

- Data reduction technique
- Data processing steps
- Technical basis for data processing

- Survey location data
- Site base map showing survey location or transects
- Dates and times of survey
- Interpretation results
- Theoretical assumptions for the interpretation
- Equipment used
- Data format (digital format, ASCII, SEG B.,)

5.6 QUALITY ASSURANCE/QUALITY CONTROL

The following QA procedures apply to all geophysical instrumentation and their use during data acquisition.

- Document all data transmittals on standard forms supplied by the geophysical subcontractor. Copies of these forms will be maintained with the field files on site.
- Operate geophysical instrumentation in accordance with operating instructions supplied by the manufacturer, unless otherwise specified in the work plan.
- Monitor battery voltage levels for all instruments each day throughout the survey. Charge or replace battery packs when voltage levels fall below the recommended level specified by geophysical equipment manufacturers.

6. Records

The FM is responsible for documenting all field activities in the field notebook. The FM should also oversee all subcontractor activities and ensure that their documentation is complete. The specific procedures used in the field shall be documented in the site characterization report or similar deliverable.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Dobrin, M. B. and C. H. Savitt. 1988. *Introduction to Geophysical Prospecting*. McGraw-Hill.

Sheriff, R. E. 1991. *Encyclopedic Dictionary of Exploration Geophysics*. Tulsa, OK: Society of Exploration Geophysics.

Telford, W. M., L. P. Geldart, R. E. Sheriff, D. A. Keys. 1998. *Applied Geophysics*. Cambridge University Press.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

9. Attachments

None.

Surface Water Sampling

1. Purpose

The purpose of this standard operating procedure is to establish standard protocols for use in sampling surface water by all United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most current version of the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e. Remedial Project Manager or QA manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that all project field personnel follow these procedures when sampling surface water. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

Surface water bodies that could be affected by a release from an investigation site may be selected for sampling. This procedure describes sample collection methods for a surface water sampling program.

5.1 SELECTION OF SAMPLING TECHNIQUES

Proper selection of sampling points and collection methodology are essential to meeting the objectives of a surface water sampling program. The data quality objectives and the conceptual site model should be used to determine all sampling methods and parameters. Sampling points should be selected for collection of surface water samples on the basis of characteristics of the surface water body to be monitored, the location of the body of surface water, and its hydrologic boundaries with respect to the site. Other considerations include the contaminants of concern, logistical considerations, such as access to the surface water body, the direction of flow, and determination of a background location.

Methods of collecting surface water samples vary from hand sampling procedures at a single point to sophisticated, multipoint sampling techniques. The number and type of samples to be collected depends on the characteristics of the body of water, the amount of suspended sediment that a moving body carries, the size of the discharge area at the site, and other factors. Multipoint sampling techniques apply to larger bodies of water; the samples are composited to provide a more representative sample.

Whenever possible, the sampling device, either disposable or constructed of a nonreactive material, should hold at least 500 milliliters to minimize the number of times the liquid must be disturbed, thus reducing agitation of any sediment layers. A 1-liter polypropylene or stainless steel beaker with a pour spout and handle works well. Any sampling device might contribute contaminants to a sample. The correct sampling device will not compromise the integrity of the sample and will give the desired analytical results.

5.1.1 Shallow Water Body Surface Water Sample Collection

A dip or grab sample is appropriate for a small body of water, or for collecting near-surface samples in a larger surface water body. The sampling method involves filling a sample container by submerging it either just below the surface, or by lowering the container to a desired depth by using a weighted holder. For shallow bodies of surface water, hold the sample container carefully just beneath the water surface to avoid disturbing the streambed and stirring the sediment. Position the container's mouth so that it faces upstream, while the sampling personnel are standing downstream. Any preservative added to the sample should be added after sample collection to avoid loss of preservative. Alternatively, a transfer device may be dipped into the water, and then the contents transferred to the appropriate container containing the preservative. For near-surface sample collection in a large surface water body, a pond sampler may be used if an extended reach is required to collect a representative sample. A pond sampler consists of a single use sample container attached to a telescoping, heavy-duty, aluminum pole via an adjustable clamp attached to the end. The collection technique for shallow surface water samples can be used for near-surface samples in a large surface water body.

5.1.2 Deep Surface Water Sample Collection

For deeper surface water bodies, either sample containers or transfer devices may be used to collect a sample. A weighted holder that allows either a sample transfer device or a sample container to be lowered, opened for filling, closed, and returned to the surface is suggested for sampling deeper surface water bodies. This is because concentrations of constituents near the surface of a deeper body of surface water might differ from the total concentration distributed throughout the water column cross section and thus a surface sample would not be representative of the water body. An open container that is lowered and raised to the surface at a uniform rate so that the bottle is just filled on reaching the surface is appropriate for deeper stagnant water bodies, however this method does not collect a truly representative sample in deeper flowing surface water bodies.

Kemmerer Samplers. Collect samples near the shore unless sampling from a boat is feasible and permitted. If a boat is used, the body of water should be cross-sectioned, and samples should be collected at various depths across the water in accordance with the specified work plan. For this type of sampling, use a weighted-bottle sampler to collect samples at any predetermined depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper, and a line that is used to open the bottle and to lower and raise the sampler during sampling. The sampler can be either fabricated or purchased. The general procedure for using the sampler is as follows:

1. Assemble the weighted bottle sampler.
2. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely.
3. Pull out the stopper with a sharp jerk of the sampler line.
4. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.
5. Raise the sampler and cap the bottle.
6. Wipe the bottle clean. The bottle can also be used as the sample container.

Teflon Bailers: Teflon bailers have also been used to collect samples in deep bodies of water. When the use of Teflon bailers is deemed appropriate for sampling water from a specific depth, the bailers shall be equipped with a check valve that closes during sample retrieval.

Peristaltic Pump: Another method of extending the reach of sampling efforts is to use a small peristaltic pump. In this method, the sample is drawn through heavy-wall Teflon tubing and pumped directly into the sample container. This system allows the operator to reach into the liquid body, sample from depth, or sweep the width of narrow streams. However, use of the peristaltic pump is restricted to a maximum depth of 20 to 24 feet due to the physical constraints associated with vacuum pumps.

If medical-grade silicon tubing is used in the peristaltic pump, the system is suitable for sampling almost any analyte, including most organics. Some volatile stripping may occur; due to the relatively high flow rate of the pump. Therefore, avoid pumping methods for sampling volatile organics. Battery-operated peristaltic pumps are available and can be easily carried by hand or with a shoulder sling, as needed. It is necessary in most situations to change both the Teflon suction line and the silicon pump tubing between sampling locations to avoid cross contamination. This action requires maintaining a sufficiently large stock of material to avoid having to clean the tubing in the field.

Peristaltic pumps work especially well for sampling large bodies of water when a near-surface sample will not sufficiently characterize the body as a whole. It is capable of lifting water from depths in excess (but not much in excess) of 21 feet. This lift ability decreases somewhat with higher-density fluids and with increased wear on the silicone pump tubing. Similarly, increases in altitude will decrease the pump's ability to lift from depth. When sampling a liquid stream that exhibits a considerable flow rate, it may be necessary to weight the bottom of the suction line.

Use the following procedures for collecting samples using peristaltic pumps:

1. Install clean, medical-grade silicone tubing in the pump head, per the manufacturer's instructions. Allow sufficient tubing on the discharge side to facilitate convenient dispensation of liquid into sample bottles but only enough on the suction end for attachment to the intake line. This practice will minimize sample contact with the silicone pump tubing. (Some types of thinner Teflon tubing may be used.)
2. Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the tubing on the intake side of the pump. If necessary, a small weight composed of relatively inert material, which will not react with anticipated chemicals, may be used to weight the intake tubing. Heavy-wall Teflon of a diameter equal to the required pump tubing will suit most applications. (A heavier wall will allow for a slightly greater lateral reach.)
3. If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume, and then return it to the source (i.e., surface water) after the sample aliquot has been collected.
4. Fill necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as it is filled.
5. Preserve the sample, if necessary, following guidelines in the work plan. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
6. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly. Tape the cap to the bottle, and then date and initial the tape. The tape will serve as a custody seal.
7. Label the sample bottle with an appropriate tag using a solvent-free marker. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Record the information in the field logbook, and complete the chain-of-custody documents.
8. Place the properly labeled sample bottle in an appropriate carrying container.
9. Allow the system to drain thoroughly, and then disassemble and decontaminate it.

5.2 TRANSFER DEVICES

Samples from various locations and depths can be composited if project quality objectives indicate that it is appropriate; otherwise, collect separate samples. Identify approximate sampling points on a sketch of the water body. Use the following procedures for collecting samples using transfer devices:

1. Submerge a stainless steel dipper or other suitable device, causing minimal disturbance to the surface of the water. Note the approximate depth and location of the sample source (e.g., 1 foot up from bottom or just below the surface).
2. Allow the device to fill slowly and continuously.
3. Retrieve the dipper or device from the surface water with minimal disturbance.
4. Remove the cap from the sample bottle and slightly tilt the mouth of the bottle below the dipper or device edge.
5. Empty the dipper or device slowly, allowing the sample stream to flow gently down the side of the bottle with minimal entry turbulence.

6. Continue delivery of the sample until the bottle is almost filled. Check all procedures for recommended headspace for expansion.
7. If necessary, preserve the sample according to guidelines in the work plan. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
8. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly. Tape the cap to the bottle using solvent-free tape, and then date and initial the tape. The tape will serve as a custody seal.
9. Label the sample bottle with an appropriate sample tag using a solvent-free marker. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Record the information in the field logbook, and complete the chain-of-custody form.
7. Dismantle the sampler, wipe the parts with terry towels or rags, and store them in plastic bags for subsequent disposal. Follow all instructions for proper decontamination of equipment and personnel.

Use the following procedures for collecting samples using peristaltic pumps:

1. Install clean, medical-grade silicone tubing in the pump head, per the manufacturer’s instructions. Allow sufficient tubing on the discharge side to facilitate convenient dispensation of liquid into sample bottles but only enough on the suction end for attachment to the intake line. This practice will minimize sample contact with the silicone pump tubing. (Some types of thinner Teflon tubing may be used.)
2. Select the length of suction intake tubing necessary to reach the required sample depth and attach it to the tubing on the intake side of the pump. If necessary, a small weight composed of relatively inert material, which will not react with anticipated chemicals, may be used to weight the intake tubing. Heavy-wall Teflon of a diameter equal to the required pump tubing will suit most applications. (A heavier wall will allow for a slightly greater lateral reach.)
3. If possible, allow several liters of sample to pass through the system before actual sample collection. Collect this purge volume, and then return it to the source (i.e., surface water) after the sample aliquot has been collected.
4. Fill necessary sample bottles by allowing pump discharge to flow gently down the side of bottle with minimal entry turbulence. Cap each bottle as it is filled.
5. Preserve the sample, if necessary, following guidelines in the work plan. In most cases, place preservatives in sample containers before sample collection to avoid overexposure of samples and overfilling of bottles during collection.
6. Check that a Teflon liner is present in the cap, if required. Secure the cap tightly. Tape the cap to the bottle, and then date and initial the tape. The tape will serve as a custody seal.
7. Label the sample bottle with an appropriate tag using a solvent-free marker. Be sure to label the tag carefully and clearly, addressing all the categories or parameters. Record the information in the field logbook, and complete the chain-of-custody documents.
8. Place the properly labeled sample bottle in an appropriate carrying container.
9. Allow the system to drain thoroughly, and then disassemble and decontaminate it.

Multipoint sampling techniques that represent both dissolved and suspended constituents and both vertical and horizontal distributions are applicable to larger bodies of water. Subsequent to sample collection, multipoint sampling techniques may require a compositing and sub-sampling process to homogenize all the individual samples into the number of subsamples required to perform the analyses of interest. Homogenizing samples is discouraged for samples collected for volatile organic analysis, because aeration causes a loss of volatile compounds. If collection of composite samples is required, then include the procedure for compositing in the project-specific work plan.

The sampling devices selected must not compromise sample integrity. Collect samples with either disposable devices, or devices constructed of a nonreactive material, such as glass, stainless steel, or Teflon. The device must have adequate capacity to minimize the number of times the liquid must be disturbed, reducing agitation of any sediment layers. Further, the device must be able to transfer the water sample into the sample container without loss of volatile compounds. A single- or double-check valve or stainless steel bailer made of Teflon equipped with a bottom discharging device may be used.

All equipment used for sample collection must be decontaminated before and after use in accordance with Procedure I-F, *Equipment Decontamination*.

5.3 TYPICAL FIELD SAMPLING SUPPLIES AND EQUIPMENT/APPARATUS

Sampling supplies

- Work Plan
- Maps/Plot plan
- Tape measure
- Survey stakes, flags, or buoys
- Camera
- Stainless steel, plastic, or other appropriate composition (e.g., Teflon) bucket
- Laboratory supplied sampling containers
- Ziploc plastic bags for samples, and sample jars
- Logbook
- Labels
- Chain of Custody forms
- Site description forms
- Cooler(s)
- Ice

Equipment/Apparatus

- Decontamination supplies/equipment
- Spade or shovel

- Spatula
- Scoop
- Trowel
- Task-specific surface water sampling equipment

6. Records

During the completion of sampling activities, fill out the sample logbook and transmit forms to the CTO Manager for storage in project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-F, *Equipment Decontamination.*

9. Attachments

None.

Monitoring Well Installation and Abandonment

1. Purpose

This standard operating procedure describes the methods to be used by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel during the installation of groundwater monitoring wells. It describes the components of monitoring well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 FILTER PACK

Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.2 ANNULUS

The annulus is the downhole space between the borehole wall and the well casing and screen.

3.3 BRIDGE

An obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.4 GROUT

Grout is a fluid mixture of cement and water that can be forced through a pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 SIEVE ANALYSIS

Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4. Responsibilities

CTO Managers are responsible for issuing WPs that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and, possibly, state regulatory agencies enforce regulations that may include well construction and installation requirements. The CTO Manager shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The CTO Manager or designee shall review all well construction logs on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well installation and abandonment have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications are implemented in the field. The qualifications for the FM include a degree in geology, hydrogeology, civil/geotechnical/environmental engineering, or equivalent with at least 2 years of field experience in the installation of monitoring wells.

Field sampling personnel are responsible for the implementation of this procedure.

The onsite geologist/hydrogeologist/engineer is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within Procedure I-B-1, *Soil Sampling.*

5. Procedures

5.1 CONSIDERATIONS FOR MUNITIONS AND EXPLOSIVES OF CONCERN

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission

(ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 BACKGROUND INFORMATION

The primary objectives of installing a monitoring well at a site are: to observe groundwater levels and flow conditions; to obtain samples for determining groundwater quality; and to evaluate the hydraulic properties of water-bearing strata. To achieve these objectives, it is necessary to satisfy the following criteria:

- Construct the well with minimum disturbance to the formation.
- Construct the well with materials that are compatible with the anticipated geochemical environment.
- Properly complete the well in the desired zone.
- Adequately seal the well with materials that will not interfere with the collection of representative water samples.
- Sufficiently develop the well to remove drilling fluids or other additives or conditions associated with drilling, and provide unobstructed flow to the well.

The proper design and construction of monitoring wells requires an understanding of site geology and hydrogeology, and knowledge of contaminant transport in subsurface materials.

A significant difference between monitoring wells and production or “water” wells is that the intake section of monitoring wells is often purposely completed in a zone of poor water quality and/or poor yield. The quality of water entering a monitoring well can vary from drinking water to a hazardous waste or leachate. In contrast, production wells are normally designed to efficiently obtain water from highly productive zones containing good quality water. The screen of a monitoring well often extends only a short length (typically 10 feet or less) to monitor hydraulic conditions within, and obtain water samples from, selected water-bearing intervals. In contrast, water wells are often designed to obtain economic quantities of water from multiple zones of water-bearing strata.

5.3 MONITORING WELL DESIGN CONSIDERATIONS

The following information was compiled from a number of technical references. For additional information related to monitoring well installation, consult the references listed in Section 8.

5.3.1 Well Placement

Select the location of a monitoring well according to the purpose of the monitoring program, which will vary among different sites and may include detection of contaminants in groundwater, verification of contaminant migration predictions, the monitoring of leachate at a landfill site, or remediation of a contaminated site. Each of these purposes will require a specialized array of monitoring locations and completion intervals, and a specific sampling program. Therefore, design the monitoring well network to satisfy the needs of the particular situation.

Determine the position of a monitoring well in a contaminant flow path for a monitoring effort based on the interpretation of preliminary data. These data shall be sufficient to facilitate identification of potential contaminant sources. Also consider site history, topography, climate, surface hydrology, and the location of nearby pumping wells.

Design the layout of the groundwater monitoring network following preliminary evaluation of the approximate direction of groundwater flow. A minimum of three wells is necessary to estimate local hydraulic gradients. Ideally, at least one well will be located hydraulically upgradient, and two or more wells strategically located hydraulically downgradient of each potential contaminant source. Determination of the horizontal and vertical extent of a contaminant plume is often an iterative process requiring the installation and sampling of wells in several phases.

Install monitoring wells hydraulically downgradient and as close as physically possible to the areas of suspected contamination in order to immediately detect releases from a hazardous waste site. Locate additional monitoring wells based on the interception of potential groundwater flow paths and direction of contaminant migration.

The placement of groundwater monitoring wells shall also consider the three-dimensional nature of groundwater flow. Significant vertical gradients and heterogeneous and/or anisotropic hydraulic conditions may exist at a site. Thus, the direction of groundwater flow may not necessarily coincide with the apparent horizontal gradient observed by the triangulation provided by three monitoring wells. Determine the completion intervals of existing wells prior to the calculation of groundwater gradient directions. Consider temporal/seasonal groundwater flow conditions if the monitoring well network is located near existing active well fields, near tidal zones, or near ephemeral surface water (e.g., canals, dry river beds).

5.3.2 Well Depth and Screened Interval

A detailed understanding of the site stratigraphy, including both horizontal and vertical extent of geologic formations, is necessary to identify zones of different permeabilities, and discontinuities, such as bedding planes, fractures, or solution channels. Groundwater flow and/or contaminant transport beneath the site preferentially occur in the more permeable zones. Equally important is the identification of relatively low permeability zones that may impede migration of contaminants. The occurrence and movement of groundwater in the subsurface is closely related to lithology. Thus, geologic conditions will influence the location, design, and methods used to locate and install monitoring wells.

The depth of a monitoring well is determined by the depth of one or more water-bearing zones that are to be monitored. For example, if preliminary soil borings indicate that multiple water-bearing zones are present at a site, and it is believed that zones other than the uppermost zone may be impacted by surface contamination, a well should be completed in each individual water-bearing zone encountered. Where two or more saturated zones occur beneath a site, and the intent of the monitoring program is to monitor water quality in the lower zone, the monitoring well will generally require surface casing to isolate the upper water-bearing zone from the deeper zone prior to drilling into the deeper zone.

In multiple aquifer systems, highly variable conditions may occur. For example, an overlying unconfined aquifer may be contaminated, whereas the underlying confined aquifer may not contain contaminants. Exercise extreme care to ensure that the installation/completion of monitoring wells does not cause cross-contamination of the aquifers. In these cases, it may be preferable to install surface casing through the contaminated aquifer to minimize the possibility of cross-contamination to the lower aquifer system.

Characteristics of lithologic materials encountered at the site, such as the degree of consolidation and grain size, also influence the type of well completion. In unconsolidated alluvial deposits, screened well intakes are typically used. An emplaced filter pack, consisting of well-sorted, clean, inert silica sand with a grain size and well screen slot size appropriate for the formation, typically is used to filter out fine-grained materials present within formations encountered in the borehole. Where permeable, consolidated formations are present, casing may be extended through overlying unconsolidated deposits and the well may be completed with a section of open borehole in the consolidated water-bearing zone. Even in these cases, however, fine-grained materials may enter the well through fractures, and if severe enough, an artificial filter pack and screened intake may be required. Also, many regulatory agencies require a screened interval installed with filter pack for all well completions.

Placement of the screened interval depends primarily on two factors: the interval to be monitored and the type of contaminants. The desired interval to be monitored shall dictate the interval to be screened. Determine which stratigraphic horizons represent potential pathways for contaminant migration by the site characterization. Short screened sections provide more specific data on the vertical distribution of contaminants and hydraulic head, while long screen intervals can result in a cumulative dilution of contamination in one zone with uncontaminated groundwater in another zone, as well as less specific information on hydraulic head. In addition, a long screened interval could potentially create vertical conduits that might result in cross-contamination.

Consider the type of contaminants involved prior to well installation. Contaminants that have a density less than water migrate differently than contaminants with a density equal to or greater than water. For example, if the contaminant in an unconfined aquifer has a density lower than water, such as diesel or gasoline, it is important to ensure that the screened interval of the well extends above the maximum seasonal elevation of the water table. Doing so facilitates an accurate determination of apparent thickness of free product in a monitoring well. In general, the screen shall extend 3 to 5 feet above the highest anticipated level of the water table when monitoring the upper portions of an unconfined aquifer.

Conversely, if the contaminant of concern has a density higher than water, such as trichloroethene (TCE), the screened interval of one or more monitoring wells should be installed just above the lower confining bed of a potentially impacted aquifer. TCE may be transported at high concentrations as a dense, nonaqueous phase liquid (DNAPL) near the source area, and migrate along the top of a confining bed at the base of an impacted aquifer.

Give special attention to interpretation of site stratigraphy when assessing DNAPL, particularly with respect to dipping beds, as it is possible for DNAPLs to effectively move hydraulically upgradient if low permeability perching horizons dip in a direction opposite the hydraulic gradient. This type of situation is important to consider when selecting monitoring well locations.

If time and budget allow, correlate conventional borehole geophysical methods and continuous cores of soil samples to yield a more complete stratigraphic characterization. A continuous profile of borehole conditions is compared to field observations and is used to select screened intervals.

5.3.3 Well Permitting

All wells shall be permitted in accordance with the regulations of the jurisdiction where well installation is occurring, if this is Navy policy for the region of activity. Contact local authorities prior to establishing well construction requirements for the project.

The permit procedure may require permit fees, site inspections, and an application signed by a registered professional geologist or engineer. Permit requirements may impact field schedules and budgets. The driller may also be required by law to be licensed and bonded. Provide documentation that all legal requirements have been met to the appropriate agencies prior to the installation of a monitoring well.

5.4 SELECTION OF DRILLING METHOD

Monitoring well installation at hazardous waste sites may involve drilling through or near hazardous materials, in areas where the extent of contamination is unknown, or through more than one geologic material or aquifer. Use of any drilling method at a hazardous waste site involves an element of risk related to the potential spread of contamination or creation of a pathway through which contaminants can migrate. Selection of a method most appropriate for site-specific conditions is essential to minimize these risks. Table I-C-1-1 provides an interpretation of how geologic conditions may influence the selection of a particular drilling method.

Most drill rigs use gasoline or diesel fuel, as well as hydraulic fluid during operation. Because these fluids are all potential contaminants, it is important to protect the drill hole and immediate area from these substances. Whenever leaking fluid from the drill rig is detected, drilling operations shall cease as soon as practical following stabilization of the drill stem, and the rig shall be moved to a safe area to be repaired.

Table I-C-1-1: Relative Performance of Different Drilling Methods in Various Types of Geologic Formations; Commonly Utilized Drilling Methods

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Loose sand and gravel	G	P	P-G	NR	E	NR	E	NR	P-E	E	E
Loose boulders in alluvium	P	P-G	G	NR	E	NR	P	NR	P	G	NR
Clay, silt	E	G	E	NR	E	NR	E	P-G	E	E	G
Shale	P	NR	E	P	E	NR	NR	E	E	E	NR
Sandstone	P	NR	G	E	NR	NR	NR	E	G	E	P
Limestone with chert	NR	NR	G	E	NR	E	NR	E	G	G	NR
Limestone with and without fractures	NR	NR	G-E	E	NR	E	NR	E	P-E	E	P
Limestone, cavernous	NR	NR	P-G	P-G	NR	E	NR	E	NR	E	NR

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Dolomite	NR	NR	E	E	NR	E	NR	E	E	E	NR
Basalts-thin layers in sedimentary rocks	P	NR	G	E	NR	NR	NR	E	G	E	P
Tuff	P	NR	G	E	NR	E	NR	E	G	G	NR
Basalts-thick layers	NR	NR	P	G	NR	E	NR	E	G	G	NR
Basalts-highly fractured	NR	NR	NR	P	NR	G	NR	E	NR	G	NR
Metamorphic rocks	NR	NR	NR-P	G	NR	E	NR	E	G	G	NR
Granite	NR	NR	NR-P	E	NR	E	NR	E	G	G	NR

E	Excellent
G	Good
NR	Not Recommended
P	Poor

* Cannot be used for analytical soil sampling

** Procedure I-H, *Direct-Push Sampling Techniques* discusses protocol associated with direct push applications.

The following sections discuss commonly used drilling methods and their applicability to installation of monitoring wells. Regardless of the drilling method selected, decontaminate all drilling equipment using Procedure I-F, *Equipment Decontamination*. Follow these procedures before use and between borehole locations to prevent cross-contamination. In addition to selecting the proper drilling technique, take other precautions to prevent distribution of any existing contaminants throughout the borehole.

5.4.1 Hollow-stem Continuous-flight Auger

Hollow-stem continuous-flight auger (HSA) is the most frequently employed method used in the environmental industry for the drilling and installation of shallow monitoring wells in unconsolidated materials. Drilling with HSA is possible in loose sand and gravel, loose boulders in alluvium, clay, silt, shale, and sandstone. HSA drilling is usually limited to unconsolidated materials and depths of approximately 150 to 200 feet. HSA drill rigs are mobile, relatively inexpensive to operate, generally cause minimal disturbance to the subsurface materials, and have the additional advantage of not introducing drilling fluids (e.g., air, mud, or foam) to the formation.

Another advantage of the HSA method is that undisturbed samples are obtained by driving a split-spoon sampler below the lead auger. Soil samples can usually be easily collected in this manner with a minimum of tripping sampling tools into and out of the hole.

Moreover, in the HSA drilling method, the well is constructed inside the HSAs as the augers are gradually removed from the ground. This method decreases the possibility of the borehole collapsing before the well is installed. HSAs shall have a nominal outside auger-flight diameter of 10 to 12 inches and a minimum inside diameter of 8 inches. Larger inside diameter auger flights are sometimes available. Well casing diameter is usually limited to 4 inches or less when using the HSA method. The difference between the inner diameter (I.D.) of the auger and the outer diameter (O.D.) of the well casing shall be at least 4 inches (i.e., a minimum 2-inch annular space) to permit effective placement of filter pack, bentonite seal, and grout without bridging.

5.4.2 Rotary Bucket Auger

Rotary bucket auger drilling, or bucket auger drilling (BAD), utilizes a large-diameter bucket auger to excavate earth materials. Excavated material is collected in a cylindrical bucket that has auger-type cutting blades on the bottom of the bucket. The bucket is attached to the lower end of a kelly bar that passes through, and is rotated by, a large ring gear that serves as a rotary table.

The kelly bar is square in cross-section and consists of two or more lengths of square steel tubing, with each successive length of tubing telescoped inside the previous length. This design permits boring to a depth several times the collapsed length of the kelly bar before having to add a length of drill rod between the kelly and the bucket. In drilling with the telescoping kelly, the bucket is typically lifted and dumped without disconnecting, thereby speeding up the process when drilling deep holes. Depths of 75 to 100 feet are achievable with most telescoping kellys. It is possible to construct wells more than 250 feet deep by this method, although depths of 50 to 150 feet are more typical.

The BAD technique is most effective in semi-consolidated or clayey formations that stand open without caving. Drilling through unconsolidated materials within the saturated zone is difficult, but not impossible if the hole is kept full of water or mud (see direct rotary methods with foam or mud). Drilling mud may be necessary, particularly in loose formations consisting of unconsolidated fine- to medium-grained sands and silts. In the right conditions, a bucket auger bit will remove a cylinder of material 12 to 24 inches deep with each run. Therefore, samples obtained by the BAD method are representative of the formation being drilled, unless sloughing or caving of the borehole walls occurs.

Boreholes drilled with the BAD technique generally range from 18 to 48 inches in diameter. Because of the large diameter of the borehole drilled with this technique, and the common need to add either water or mud to maintain the borehole in unconsolidated, near-surface deposits, it is recommended to use this method only for the installation of surface casing through the first water-bearing unit at a hazardous waste site.

5.4.3 Direct Rotary with Foam or Mud

Direct rotary drilling (DRD) techniques involve the use of various types of drilling fluids, which typically include air, foam, and mud. In each of the DRD methods, drilling fluids are circulated down through the inside of the drilling pipe into the borehole, and then up through the annulus between the drilling pipe and the borehole wall to carry drill cuttings up to the surface. The drilling fluids may also be used for stabilizing the borehole wall, which may be especially useful in unconsolidated, caving formations. In this section, the DRD method and its use with either foam or mud are discussed.

A variety of bit types may be used with each of these drilling fluids, depending on the type of formational material encountered; however, typically, the tri-cone or roller bit is used. The drilling bit is attached directly to a heavy section of drill pipe called a drill collar, which is attached to help keep the borehole straight. The drill collar is in turn attached to the drill pipe and the kelly.

General types of drilling fluids available for use with the DRD method include water with clay additives, water with polymeric additives, water with clay and polymeric additives, and foams (comprised of air or water, surfactants, and occasionally clays or polymers). The drilling fluid density may be adjusted during drilling to improve or resume circulation within the borehole, or to attempt to stabilize the borehole wall. A major problem with the addition of these fluids is that it is almost impossible to estimate the amount introduced into the formation through the saturated and unsaturated zones. Additionally, it is also very difficult to estimate the magnitude and duration of the impact to groundwater quality by the use of these fluids.

The drilling fluids and associated cuttings shall not be allowed to flow over the site unrestricted. A downhole circulation system, or fluid diversion system shall be used to keep the fluids and cuttings contained in a reasonable manner, yet still allow the collection of grab samples for lithologic identification.

While in some geologic situations DRD may be the most efficient method of drilling a borehole, potential problems associated with the drilling fluids usually make DRD a last-resort drilling technique for environmental purposes; one that should be avoided whenever possible.

Potential Problems of DRD with Foam or Mud

- The chemistry of the drilling fluid could adversely affect the chemistry of groundwater samples, soil samples, or the efficiency of the well (when using mud).
- Bentonite mud reduces the effective porosity of the formation around the well, thereby compromising the estimates of well recovery. Bentonite may also affect groundwater pH. Additives to adjust viscosity and density may introduce contaminants to the system or force irrecoverable quantities of mud into the formation.
- Some organic polymers and compounds provide an environment for bacterial growth, which in turn, reduces the reliability of sampling results.
- Uncontained drilling foam and/or mud may create unsafe working conditions at the surface around the rig.

Solutions

- DRD should only be utilized as a last resort.
- The hydrogeologist should ensure that the fluids used will not affect the chemistry of the soil samples and groundwater samples. One possibility is to collect samples of the drilling fluid for laboratory analysis.
- The hydrogeologist shall keep track of the amount of water and fluids introduced to the borehole in order to purge this quantity during well development.
- Provisions to contain drilling mud and foam shall be discussed in the drilling contractor scope of work.

5.4.4 Air Rotary and Air Rotary with Casing Hammer

Air rotary drilling (ARD) and air rotary with casing hammer (ARCH) force air down the drill pipe and back up the borehole and remove drill cuttings in the same manner as DRD with foam or mud. Without a casing hammer, the use of ARD techniques is best suited to hard-rock formations where the borehole will stand open on its own and circulation loss is not a major concern. ARCH is most useful in unconsolidated sediments of all types due to the use of a hardened steel casing that is driven behind the bit with a pneumatic casing hammer to keep the hole open. A combination of these two drilling techniques is very useful where unconsolidated overburden overlies consolidated rock. In this case, the casing hammer attachment would be used to set the surface casing at the top of the consolidated formation while continuing with ARD. As a well is being installed or the hole is being abandoned, the casing can be retrieved for use on another hole, or left in place to serve as surface casing.

Air from the compressor shall be filtered to ensure that oil or hydraulic fluid is not introduced into the soils and/or groundwater system to be monitored. In addition, foam or hydrocarbon-based lubricating joint compounds for the drill rods shall not be used with any rotary drilling method due to the potential for introduction of contaminants into the native materials and/or groundwater. Teflon-based joint lubricating compounds that are typically mixed with vegetable oil are available for this purpose.

Potential Problems of ARD and ARCH

- In the case of sampling with a split-spoon sampler to collect soil samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.
- Fine-grained saturated materials that may cause surging and heaving problems are common in many coastal areas. Heaving sediments may cause problems during sampling and well installation when drilling with ARD.
- Rocks and other drill cuttings may be ejected from the borehole at high velocities, creating a secondary hazard around the rig.

Solutions

- ARD and ARCH should not be used for soil sampling in shallow, unconsolidated situations where a HSA rig could be used as effectively.
- One method to compensate for heaving and surging aquifer materials is to over drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is being performed.
- Another method to control heaving sands is to add clean water to a level above the water table to create a downward pressure on the heaving materials. This additional volume of water should also be extracted during well development.
- Drill rigs shall be equipped with cyclones or equivalent devices designed to contain formation projectiles.

5.4.5 Dual Tube Casing Hammer with Reverse Air Circulation

Dual tube casing hammer with reverse air circulation (DTCH) is useful in unconsolidated sediments, but is most effective as a method for drilling through thick sequences of materials, such as coarse-grained sands and gravels. The DTCH system operates by simultaneously driving a pair of heavy gauge steel pipes into the ground while using high pressure reverse air circulation to blow air down the annulus of the two pipes and bring air and unconsolidated lithologic materials out through the inside of the inner pipe. The method does not employ a typical bit in that the formational materials are not ground up, sliced, nor cut into pieces. Instead, the bit consists of a special shoe that is used to funnel materials either into, or away from, the inner pipe, depending on whether the formational material is fine- or coarse-grained, respectively.

Typically, the method can drill through 200 feet of gravel in a day with relative ease. The inside diameter of the inner pipe is about 6 inches, with the borehole diameter being about 10 inches. Cobbles with long axes of up to 6 inches come up through the inner pipe easily. Larger conglomerate clasts must be either pushed aside or broken up using the pneumatic hammer to drive the heavy shoe down onto the clast.

Conversely, the method works poorly in clay-rich materials. The shoe acts as a large cookie cutter, forcing a plug of clay into the inner pipe, which then must be forced to the surface and physically removed from the diverter/shoe assembly with the hammer. This method should probably be avoided where large thicknesses of clay are expected to be encountered in the subsurface.

Typically, the DTCH method can drill to approximately 200 feet with standard equipment. Deeper holes will likely require a larger air volume for circulation via an additional compressor hooked up to the drilling rig. Additionally, a variation of the DTCH called “triple tube” can be used to install larger-diameter wells to depths of about 200 feet depending upon the site. This method can also be used to supply a temporary surface casing to avoid cross-contamination of deeper zones while extending the boring to greater depths.

Potential Problems of DTCH

- In the case of soil sampling with a split-spoon sampler to collect samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.

Solutions

- DTCH should not be used for sampling soil in shallow, unconsolidated situations where a HSA rig could be used as effectively.

5.5 MONITORING WELL DESIGN PROCEDURES

The designs of typical groundwater monitoring wells are depicted in Figure I-C-1-1 and Figure I-C-1-2. A discussion of the design of the individual components of a typical monitoring well is given in the following subsections.

5.5.1 Pre-installation Design Drawing

Develop a pre-installation design drawing after the borehole for the well has been completed and well-specific lithologic and hydrologic information are available. The pre-design drawing shall identify the anticipated depth of the well, the locations of the top and bottom of the screened interval, the anticipated top of the filter pack, the anticipated top of the bentonite seal, and the locations of centralizers (if applicable). In addition, calculate the volumes of sand, bentonite, and grout anticipated to be placed in the annular space of the well. Maintain the drawing as documentation of the well design.

5.5.2 Casing Selection

The cased section of a monitoring well is a pipe without slots or openings, which is installed to prevent the well from directly accessing formations above the screened interval. The casing isolates the screened interval.

The selection of appropriate casing materials must take into account several site-specific factors, such as: (1) geology, (2) geochemistry, (3) well depth, (4) size and type of equipment to be used in the well, and (5) the types and concentrations of suspected contaminants. In addition, consider several other logistical factors, including drilling method, cost, and availability.

Typical casing materials comprise polyvinyl chloride (PVC), chlorinated PVC, fiberglass reinforced plastic, Teflon, galvanized steel, carbon steel, Type 304 stainless steel, and Type 316 stainless steel. Casing materials must be compatible with the environment into which they will be placed. Metallic casings are most subject to corrosion, while thermoplastic casings are most subject to chemical degradation. Some thermoplastic materials are susceptible to sorption and desorption of chemicals. The extent to which these processes occur is related to water quality, the concentration of contaminants, and the type of casing materials. Choose casing material with knowledge of the existing or anticipated groundwater chemistry. If non-aqueous phase liquids (light non-aqueous-phase liquid or DNAPL) are potentially present at a site, careful consideration of the concentrations and types of chemicals that may come into contact with the casing must be made to insure the casing will not degrade over time. Table I-C-1-2 presents the relative compatibilities of some typical casing materials.Table I-C-1-2: Relative Chemical Compatibility of Rigid Well-Casing Material

	PVC [a] 1	Galvanized Steel	Carbon Steel	Low-Carbon Steel	Stainless [b] Steel 304	Stainless [b] Steel 316	Teflon [c]
Buffered weak acid	100	56	51	59	97	100	100
Weak acid	98	59	43	47	96	100	100
Mineral acid/high solids	100	48	57	60	80	82	100
Aqueous/organic mixtures	64	69	73	73	98	100	100
Percent overall rating [d]	91	58	56	59	93	96	100

[a] PVC casing shall not be installed in a groundwater environment containing chlorinated solvent or other destructive contaminants where the concentration of organics is greater than 1 part per million, and where the desired detection limit is less than 25 part per billion.

[b] Type 316 stainless steel screen and/or casing shall be used rather than type 304 when conditions are unknown and the lifespan of the monitoring well is to be greater than 5 years, or where the pH (indicates the hydrogen ion concentration – acidity or basicity) is less than 4.5, or where chloride concentration is greater than 1,000 part per million.

[c] Trademark of E.I. DuPont de Nemours

[d] Overall rating based on scale of 0 to 100 with 0 being the least compatible and 100 being the most compatible.

Besides chemical compatibility, a second consideration for specification of casing materials is the depth of the monitoring well. Well installations greater than 150 feet deep require casing materials of greater structural strength. In the case of PVC casing, Schedule 80 PVC rather than Schedule 40 may be required to prevent over-stressing of the casing couplings. The build-up of heat during grout setup might adversely affect some thermo-plastic materials.

Regardless of the type of casing materials, use only flush-threaded couplings. Flush-threaded couplings ensure that no screws, mechanical adapters, glues, or solvents are necessary to join individual sections. Steel conductor casing shall be welded at the joints, and the joint shall be at least as thick as the thickness of the casing wall. The weld shall be fully penetrating and shall meet the standards of the American Welding Society. Outside steel collars may be used to increase the strength of the welded joint. Do not use Teflon tape on PVC or stainless steel casing joints because it reduces the tensile strength of the joints.

The selection of an appropriate casing diameter is also important. The I.D. shall be 4 inches or greater to allow better access to the well and more rigorous well development than is commonly possible with smaller-diameter wells. Wells with casing smaller than 4-inch I.D. shall only be installed with the approval of the QA Manager or Technical Director. Wells greater than 150 feet in depth may require diameters larger than 4 inches to ensure that development and sampling equipment can be moved easily through the well. In addition, wells designed for groundwater extraction shall have a casing diameter large enough to accommodate a pump capable of achieving the appropriate pumping rate. The borehole in which the well is to be installed shall be a minimum of 4 inches larger in diameter than the O.D. of the well casing.

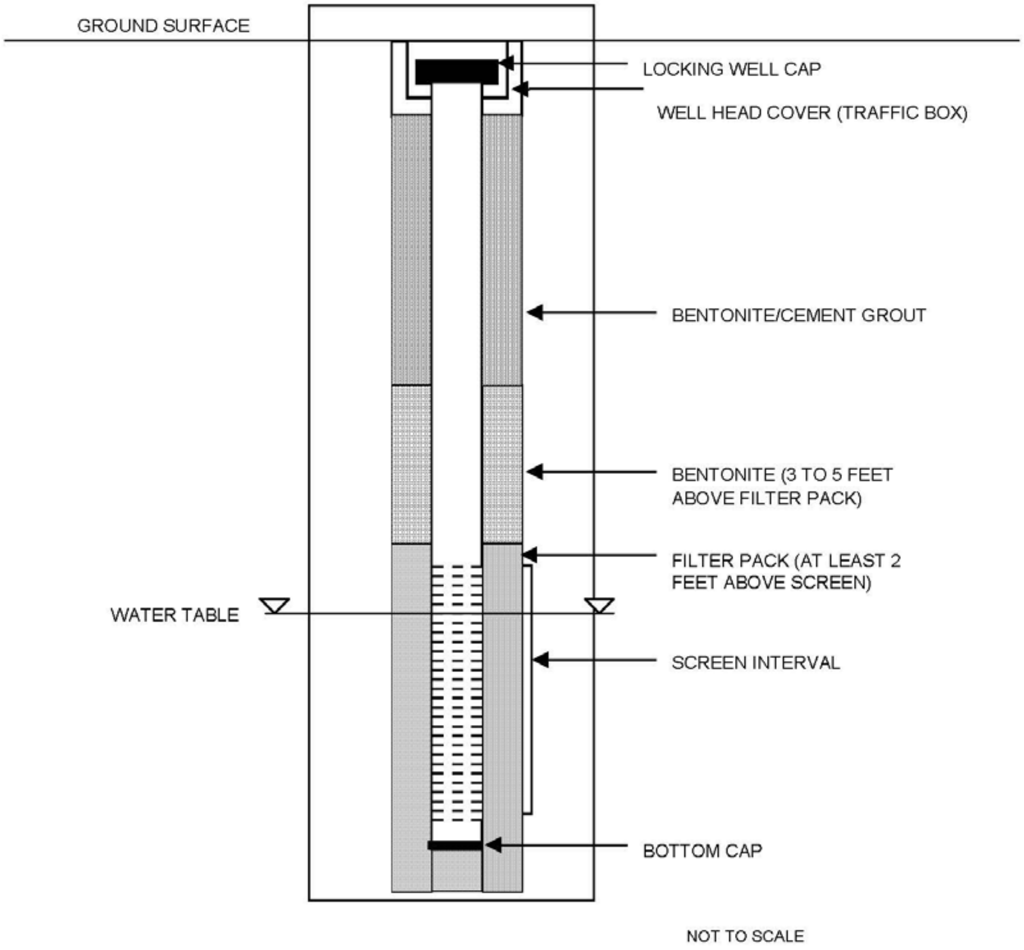


Figure I-C-1-1: General Cross Section of Monitoring Well, Unconfined Water Bearing Zone

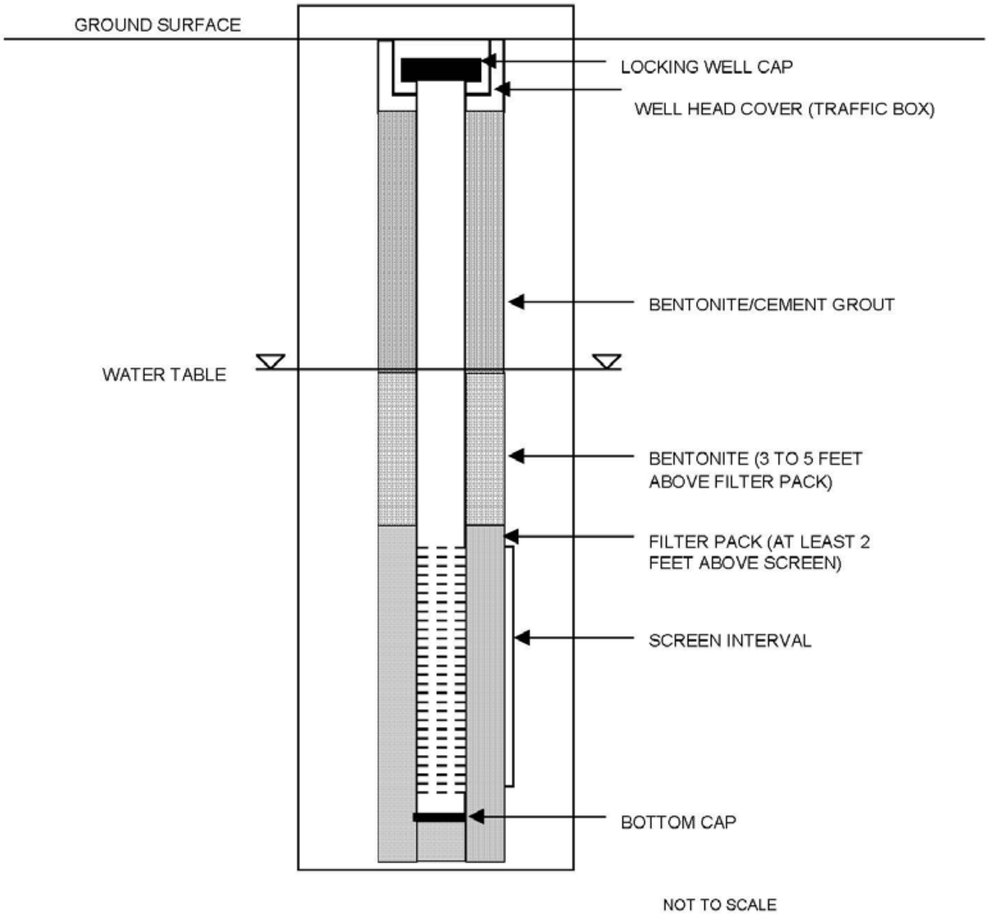


Figure I-C-1-2**: General Cross Section of Monitoring Well, Confined Water Bearing Zone**

5.5.3 Well Screen Selection

The screened section of the monitoring well allows groundwater to flow freely into the well, while retarding movement of fine-grained lithologic materials into the well. When designing a well screen, consider important factors, such as type of well screen material, length of the screened section, location of the screened section, the intake opening (slot) size, the type of intake opening, and size of filter pack to be utilized.

Five factors directly affect the performance of the monitoring well and are evaluated in the selection of an appropriate screen: (1) chemical resistance/interference, (2) screen length, (3) screen placement, (4) intended use of well (e.g., long-term groundwater extracted); and (5) intake opening size.

Selection of a screen material that provides chemical resistance and minimizes interference follows the same basic procedures as the selection of an appropriate casing material (see Table I-C-1-2). Some typical screen materials consist of PVC, Teflon, Type 304 stainless steel, and Type 316 stainless steel. Again, use only flush-threaded couplings. Screen sections constructed of different metals in the same well may cause electrochemical reactions that could rapidly degrade the casing or screen; therefore, do not use this type of composite well construction. In addition, construct wells intended for long-term groundwater extraction with well screen rather than slotted casing for facilitating redevelopment.

Selection of the screen length depends on its primary use(s). Most monitoring wells function as both groundwater sampling points and piezometers. Shorter-screened sections provide more specific data on vertically distributed contaminants, hydraulic head, and flow, and are generally preferred to longer-screened lengths. Saturated sections in groundwater monitoring wells shall be limited to between 5 and 10 feet in length; however, longer intervals may be justified in certain circumstances with approval of the QA Manager or Technical Director.

Placement of the screened interval within a groundwater monitoring well depends primarily upon two factors: the discrete interval and the type of contaminants to be monitored. The location of the discrete interval to be monitored will dictate the location of the screened interval within a monitoring well; however, also consider the characteristics of the contaminants to be monitored (i.e., light, non-aqueous phase liquid; dense, non-aqueous phase liquid) when choosing placement of the screened interval.

An additional consideration in the design of the screened section of the well is the hydraulic characteristics of the water-bearing zone that is to be monitored (i.e., confined or unconfined). If an unconfined zone is being monitored for contaminants that are less dense than water (e.g., gasoline, diesel, waste oil), place 3 to 5 feet of screened interval above the highest level of the water table to allow for evaluation of fluctuations in water level and to ensure that contaminant phases less dense than water can be observed. Conversely, if an unconfined zone is being monitored for contaminants that are denser than water (e.g., chlorinated solvents), place approximately 5 feet of screened interval (maximum) just above the confining unit at the base of the water-bearing zone to facilitate detection of the dense-phase contaminants. In the case of a confined water-bearing zone, use a maximum-screened interval of approximately 5 feet.

Selection of an appropriate intake opening size is critical to the performance of the monitoring well and to the integrity of groundwater samples obtained from the well. The size of the intake openings can only be determined following the selection of an appropriate filter pack, which itself is selected based upon the grain-size of the formation. An intake size is generally designed to hold back between 85 to 100 percent of the filter pack material. Figure I-C-1-3 can be used to select appropriate intake opening sizes. The screen slots shall be factory-made (or formed).

5.5.4 Filter Pack Design

Filter pack material shall be clean and chemically stable within the monitoring well environment to minimize addition to, or sorption from, the groundwater. Filter pack shall meet the following minimum specifications:

- Filter pack material shall be at least 95 percent silica, consisting of hard, durable grains that have been washed until free of dust and contamination, and graded.
- Filter pack material shall not be angular and non-uniform such that it will bridge in the annular space, leaving a void or poorly packed materials that can consolidate or settle after construction.
- Select filter pack to meet the grading specification determined from sieve analysis of the geologic formation to be screened, if available.
- Filter pack material shall be commercially packaged in bags that prevent the entrance of contaminants, and allow proper handling, delivery, and storage at the monitoring well site. Do not use material delivered in broken bags for monitoring well construction.

In investigations where there are limited data on site conditions prior to monitoring well installation, select the filter pack size prior to field activities based on available lithologic data. Use finer filter pack sizes if fine-grained formations are anticipated to be present, and use coarser-grained filter packs in coarser lithologies and consolidated formations.

In investigations where sieve analysis data exist for a site prior to field activities, base selection of a proper filter pack upon the grain size of the formation materials to be monitored. Use the sieve data for the finest lithology identified in the interval to be monitored for establishing filter pack size. The U.S. Environmental Protection Agency recommends that filter pack grain size be selected by multiplying the 70 percent retained grain size of the formation materials by a factor between 4 and 6. Use a factor of 4 if the formation materials are fine-grained and uniform, and use a factor of 6 if the formation materials are coarse-grained and non-uniform. In any case, the actual filter pack used should fall within the area defined by these two curves. An example of this technique is presented in Figure I-C-1-4.

5.5.5 Annular Seal

The annular seal is placed directly above the filter pack in the annulus between the borehole and the well casing. The annular space must be sealed to prevent the migration of water and contaminants through the annulus. The annular seal is also intended to hydraulically and chemically isolate discrete water-bearing zones.

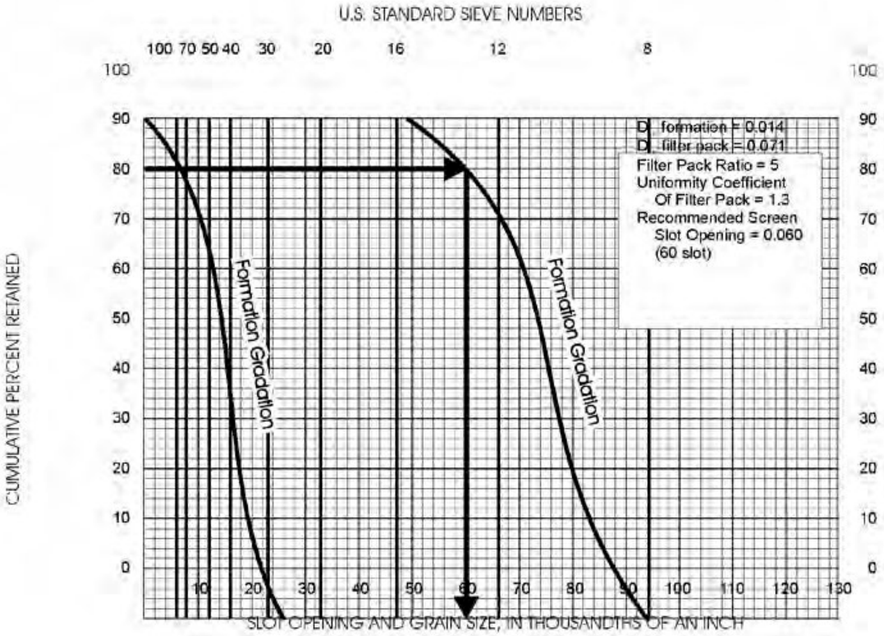


Figure I-C-1-3: Selecting Well Intake Slot Size Based on Filter Pack Grain Size

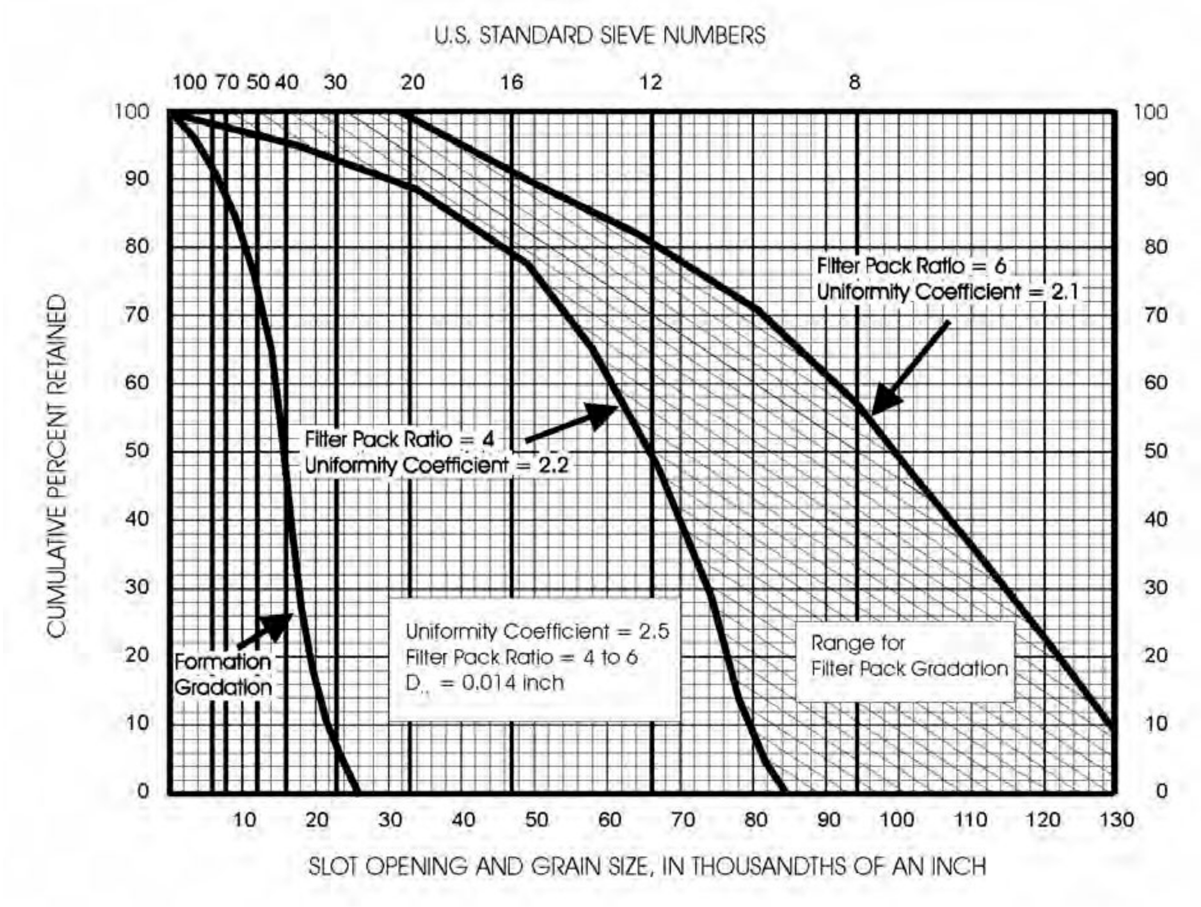


Figure I-C-1-4: Filter Pack Design Criteria

Typically, annular seals consist of two discrete sections. The first section, known as the bentonite seal, consists of a pure sodium bentonite seal. To be effective, the bentonite seal should be emplaced directly over the top of the filter pack and extend approximately 3 to 5 feet (no less than 3 feet thick). Typical materials for the seal consist of granular sodium bentonite, or sodium bentonite pellets or chips.

The second section of the annular seal typically contains grout slurry, which completely fills the remaining annular space from the bentonite seal to just below the ground surface. Grout consists of either sodium bentonite and Portland cement slurry or neat cement slurry. Give special consideration to the selection of annular seal material for wells installed in coastal areas where groundwater may contain elevated concentrations of sulfates. In this situation, use a sulfate resistant grout to prolong the usefulness of the well.

5.5.6 Surface Completion

The surface of the well shall be completed using either an above-grade (monument) style, or a flush-to-grade (traffic box) style. In either case, the protection of the wellhead at land surface is accomplished by means of a surface seal of concrete and a metal completion box surrounding the well casing. The surface seal serves to prevent infiltration of surface water and unauthorized entry, and where necessary, to provide protection from vehicular traffic.

5.6 MONITORING WELL INSTALLATION TECHNIQUES

The following general procedures describe the installation of groundwater monitoring wells.

5.6.1 General Casing and Screen Installation Techniques

Following completion of the borehole, the FM or designate will first measure the total depth of the hole to ensure that the desired depth has been attained. The lengths of casing and screen shall also be measured. These measurements shall be made with an accuracy of 0.01 feet using either a fiberglass or steel tape measure.

Installation of the casing and screen is normally accomplished by emplacing them into the well as an integral unit. Prior to installation, decontaminate individual lengths of the well casing and screen according to Procedure I-F, *Equipment Decontamination*, unless the casing and screen were certified by the manufacturer to have been properly pre-cleaned at the factory and sealed in plastic. Following decontamination, inspect each length to ensure that damaged or otherwise unsuitable sections are not used.

To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, suspend the casing and screen with a threaded hoisting plug and do not allow them to rest on the bottom of the boring unless the installation is less than 30 feet deep.

5.6.2 Centralizers

Install centralizers at the top and bottom of screened sections when using the air or mud rotary techniques for well installation. Also place centralizers at 20- to 40-foot intervals on blank casing; the FM will determine the spacing according to the depth of the well. Align the centralizers from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe. All devices used to affix centralizers to the casing shall not puncture the casing or contaminate the groundwater with which they come in contact. Centralizers shall be constructed of stainless steel.

5.6.3 Filter Pack Installation

Prior to the addition of any filter pack material, cover the top of the well casing to prevent filter pack material from entering it.

The filter pack is usually installed through HSAs, conductor casing, or a tremie pipe depending on the drilling technique used; however, if the depth to the bottom of the screened interval is less than 10 feet, and lithologic materials are sufficiently consolidated to preclude the possibility of hole collapse, the filter pack may be poured into the annular space of the well from the ground surface. This procedure applies to any drilling method.

During installation, measure the level of the top of the filter pack periodically to ensure that no bridging has occurred, and to determine the depth to the top of the filter pack. Be sure that the filter pack encloses the entire length of the screened section. For wells less than 100 feet in total depth, the filter pack shall generally extend to 2 feet above the top of the screened section of the well. For wells greater than 100 feet in total depth, an additional 1 foot of filter pack may be emplaced above the screen for each 100 feet of well depth.

An alternative to conventional monitoring well construction and installation is through the use of small diameter pre-fabricated monitoring wells, commonly referred to as “pre-pack” wells. Pre-pack wells typically consist of a well screen (slotted PVC) surrounded by sand (filter-pack) held in place by a stainless steel or polyethylene mesh. The pre-pack well assembly is commonly used in conjunction with direct-push drilling methodologies, which allows a relatively quick installation of these small diameter wells. Having the filter pack around the slotted PVC before the well screen is installed ensures that the filter pack is located directly around the well screen and minimizes the effort required for the filter pack installation.

The filter pack is normally an inert (e.g., siliceous) granular material that has a grain-size distribution chosen to retain formation materials. A sleeved screen consists of a slotted pipe base over which a sleeve of stainless steel mesh filled with selected filter media is installed. Pre-packed or sleeved screens may be used for any formation conditions, but they are most often used where heaving, running or blowing sands make placement of conventional well screens and filter packs difficult, or where predominantly fine-grained formation materials are encountered (ASTM 2010). During installation, the boring is advanced using hollow drive rods with an expendable drive point. Upon reaching the desired monitoring well installation depth, the entire well assembly (i.e., pre-pack well) is lowered to the desired depth within the hollow drive rods. At the desired depth, the hollow drive rods are retracted to a point above the screen. At this step a barrier is placed directly above the screen to prevent grout or material from entering the screened interval as the hollow drive rods are extracted from the boring. This barrier can be created either by natural formation collapse (occurring during the initial rod retraction), by gravity installation of fine-grade sand through the rod annulus, or as part of the pre-pack monitoring well components (e.g. expanding foam bridge). With the barrier in place, granular bentonite or bentonite slurry is then installed in the annulus to form a well seal. When installing pre-pack screens additional sand must be used to fill in the annular space between the pre-pack and the edge of the borehole. Furthermore, filter sand should be installed to at least 2 feet above the top of the pre-packed well screen.

Vendors offer pre-pack monitoring well components with varying outer diameters, which is typically based on the inner diameter of the hollow drill rods. These types of wells may be sampled by several methods including peristaltic pump, mini-bailer, or bladder pump to yield data of similar quality to that of conventional monitoring wells.

Following the installation of the filter pack, a surge block or large bailer shall be placed into and removed from the casing for approximately 10 minutes to set and compact the filter pack and to begin well development. Then, check the level of the filter pack again. Add more filter pack material according to the procedures described above if any settling of the filter pack has occurred. After emplacement, note the volume of filter pack material placed in the well, record it in the well completion record (Figure I-C-1-5), and compare it to the calculated volume of filter pack that was expected to have been used.

5.6.4 Annular Seal Installation

The sodium bentonite seal shall have a minimum thickness of 3 feet. Generally, to be effective the bentonite seal should extend above the filter pack approximately 3 to 5 feet. It may be constructed of powdered, granular, or pelletized bentonite, and may be emplaced as a dry solid, powder, or slurry. Use only sodium bentonite manufactured specifically for use in the drilling and construction of water wells. Typically, granular or pelletized bentonite is emplaced dry. Powdered bentonite is usually mixed with potable water to produce a slurry. Depending on the type of installation method, the bentonite may be emplaced through the HSAs, conductor casing, or tremie pipe.

In dry form, place the bentonite directly on the top of the filter pack. After emplacing each 1-foot-thick layer of dry bentonite in the well, add approximately 5 gallons of water of known chemical quality to hydrate the bentonite. Allow a minimum of 15 minutes for hydration of the bentonite seal once it is completely installed.

When emplacing the bentonite in slurry form, take care to ensure that the bentonite is thoroughly mixed, with no visible lumps to ensure the proper consistency. Then place a 1-foot layer of fine-grained silica sand over the top of the filter pack. This fine-grained sand layer will prevent infiltration of the filter pack by the bentonite slurry.

Emplace the remaining annular seal following the installation of the bentonite seal. The annular seal shall be a slurry consisting of 7 to 9 gallons of water per 94-pound bag of Portland cement Type I or II and a minimum of 3 to 5 percent bentonite (1/4 to 1/2 bags of bentonite powder per five bags of Portland cement). The slurry may be emplaced through a HSA, conductor casing, or tremie pipe, depending on the method of installation. Thoroughly mix the grout to ensure the proper consistency with no visible lumps of dehydrated powder. The rates at which the augers or pipe are withdrawn and the slurry added will be such that the level of the grout within the well annulus is just below the lowermost auger or pipe.

If a tremie pipe is used, emplace the annular grout seal by pumping through a pipe with a minimum 1-inch I.D., in one continuous pour, from the top of the transition seal to the ground surface. Place the bottom of the tremie pipe about 5 to 10 feet above the transition seal, depending on the stability of the hole and impact velocity of the grout.

A tremie pipe is not required for annular seals less than 10 feet from the ground surface to the top of the transition seal or for grouting within dual wall drill strings or HSAs. Measure the volume of grout seal material placed in the well, record it in the well construction log, and compare it with the calculated volume. The slurry shall extend from the top of the bentonite seal to a depth of approximately 2 feet below ground surface (bgs).

5.6.5 Annular Seal "Set Time" and Setting

Let the annular grout seal set at least 12 hours before disturbing the casing or well so that separations or breaks do not occur between the seal and the casing, or between the seal and the borehole. Development of the well is prohibited until the grout seal has set. Likewise, the concrete slab, traffic box, and/or casing riser of the surface completion shall not be poured and constructed until the grout seal has set. Top off any settlement of the grout seal as soon as possible after it sets. Record all pertinent data on the well construction log.

5.6.6 Surface Completion

The surface of a groundwater monitoring well shall be either an above-ground completion or as a flush-to-ground completion. Regardless of the method, each monitoring well shall have, at a minimum, a casing cap, concrete slab and annular seal, and a locking protective casing or locking vault. Although wellheads vary in size, effort should be made to use a consistent size wellhead or similar completion per site.

In an above-ground completion, the protective casing or monument is installed around the top of the well casing within a cement surface seal. A 2-foot-long by 2-foot-wide cement pad with a minimum thickness of 3 inches is constructed around the protective casing. Type 1 Portland cement, which meets the requirements of CLASS A standards, is used for the surface seal. Inspect the monument prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the monument in a plumb position with 2 to 3 inches of clearance between the top of the well casing and the lid of the monument. The monument shall extend at least 18 inches above grade and at least 12 inches below grade. Construct a minimum of three concrete-filled posts around the well to protect it from vehicular damage.

Inside the monument, cut or scribe two permanent survey marks, approximately 0.25 inches apart, into the top of the well casing, and also permanently mark the well with its identification number. Permanent marks may include painting, marking, or engraving on the protective casing or surface completion. An alternate option may be to attach a non-corroding, imprinted metal tag to part of the well. Cover the top of the well casing with a slip cap or locking cap to prevent debris from entering the well. Fit the monument with a casehardened lock to prevent unauthorized entry.

In a flush-to-ground completion, the protective casing or traffic box is installed around the top of the well casing, which has been cut off slightly below grade. The traffic box has a lid that is held firmly in place by bolts and has a flexible O-ring or rubber gasket to prevent water from entering the box. Whenever possible, wells with flush completions should not be placed in low spots where surface water can accumulate. If this is unavoidable, consider an aboveground completion. The traffic box is set within a cement surface seal slightly above grade to deflect surface water flow away from the well. The surface seal must form an apron at ground surface that is at least 2 feet wide and 4 inches thick. The concrete apron must slope away from the well (a minimum of 1 percent) to prevent surface water leakage into the well head (DOH 2009). An effort should be made to standardize the appearance of the well completions at a particular site. Type 1 Portland cement, which meets the requirements of CLASS A standard, is used for the surface seal. Where monitoring well protection must be installed flush with the ground, an internal cap should be fitted on top of the riser within the manhole or vault. This cap should be leak-proof so that if the vault or manhole fills with water, the water will not enter the well casing. The cap should also be able to lock to prevent unwanted access or tampering with the well. Ideally, the manhole cover cap should also be leak-proof (ASTM 2010). Inspect the traffic box prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the traffic box in a level position that leaves 2 to 3 inches of clearance between the top of the well casing and the lid of the traffic box. Regular maintenance may be necessary to maintain the integrity of the seals and pads protecting the wells.

Cut two permanent survey marks into the top of the well casing, approximately 0.25 inches apart, and also permanently mark the well with its identification number. Cover the top of the well casing with a lockable cap to prevent debris from entering the well. Also fit the lockable cap with a casehardened lock to prevent unauthorized entry.

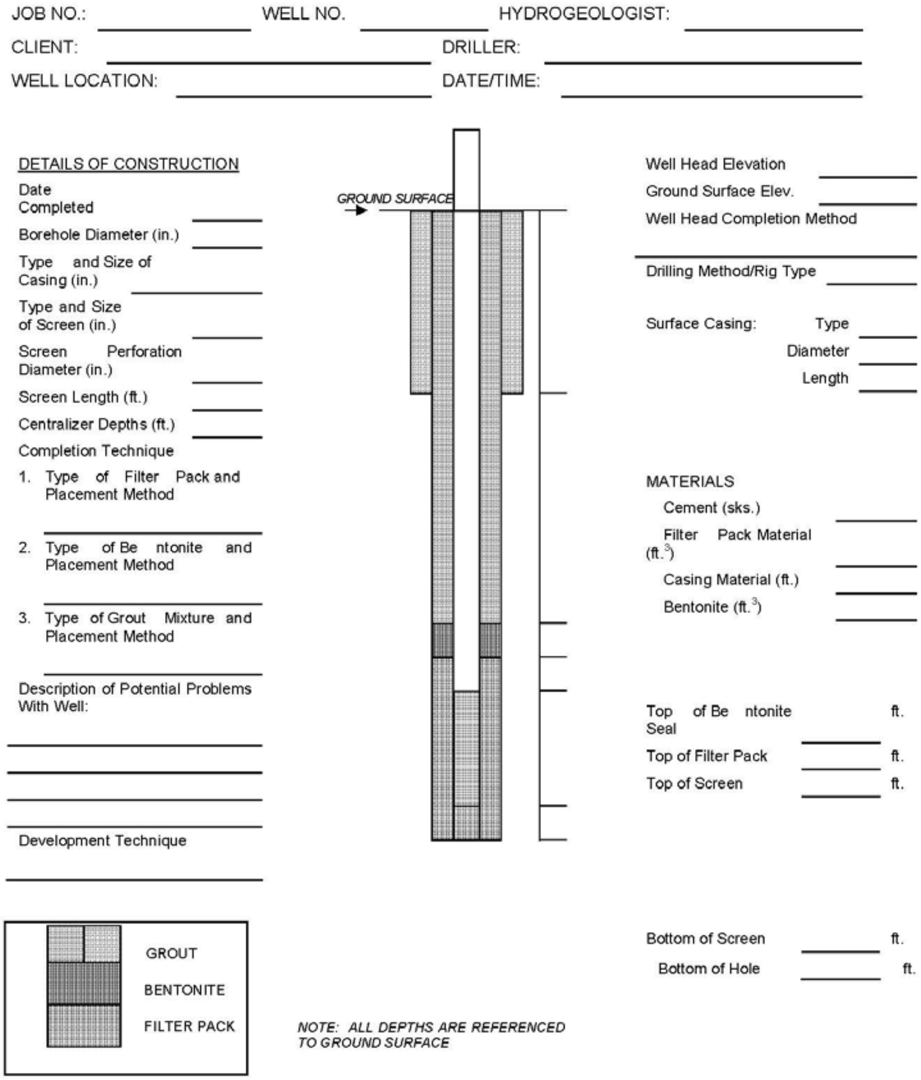
In areas where there is a high probability of damaging the well (high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, or other means. The level of protection should meet the damage threat posed by the location of the well (ASTM 2010).

5.6.7 Installation of Surface Casing

The use of surface casing may be required to minimize the potential for cross-contamination of different hydrogeologic zones within the subsurface of a site. The depth of placement of the surface casing shall be based on site-specific geologic knowledge obtained from lithologic samples collected in situ during the drilling of the well boring.

If a surface casing is to be installed permanently along with the well, grout it in place. The borehole shall be of sufficient diameter that a tremie or grout pipe can be easily placed between the borehole wall and the outside of the surface casing. After the desired placement depth is reached and the drilling tools are removed from the borehole, lower the casing into the borehole and center it. The bottom of the surface casing may be plugged or driven into the sediment at the base of the borehole to keep grout from entering the casing, if necessary.

Install grout through the tremie pipe and pump it from the bottom of the casing to ground surface. As the grout is being placed, raise the tremie pipe slowly to avoid excessive backpressure and potential clogging of the tremie pipe. After the grout has been allowed to set for at least 24 hours, drilling and subsequent well installation can continue. The required time for grout to set before drilling can continue depends on the volume of grout emplaced; the more grout used, the longer the delay time.



JOB NO.: WELL NO. HYDROGEOLOGIST:
CLIENT: DRILLER:
WELL LOCATION: DATE/TIME:

DETAILS OF CONSTRUCTION
Date Completed
Borehole Diameter (in.)
Type and Size of Casing (in.)
Type and Size of Screen (in.)
Screen Perforation Diameter (in.)
Screen Length (ft.)
Centralizer Depths (ft.)
Completion Technique
1. Type of Filter Pack and Placement Method
2. Type of Bentonite and Placement Method
3. Type of Grout Mixture and Placement Method

Description of Potential Problems With Well:

Development Technique

Well Head Elevation
Ground Surface Elev.
Well Head Completion Method

Drilling Method/Rig Type

Surface Casing: Type
Diameter
Length

MATERIALS
Cement (sks.)
Filter Pack Material (ft.^{3})
Casing Material (ft.)
Bentonite (ft.^{3})

Top of Bentonite Seal ft.
Top of Filter Pack ft.
Top of Screen ft.

Bottom of Screen ft.
Bottom of Hole ft.

GROUT
BENTONITE
FILTER PACK

NOTE: ALL DEPTHS ARE REFERENCED TO GROUND SURFACE

Figure I-C-1-5: Well Completion Record

5.6.8 Shallow Well Completion

Due to the occurrence of shallow groundwater in some areas, there are instances when the top of the screened interval must be placed at a depth so shallow that it is impossible to install the well using the typical design for annular materials (i.e., 2 feet above the screen for filter pack followed by a 3-foot thickness of bentonite seal). In cases where the top of the screen must be placed between 4 and 6 feet bgs, use the following design alteration:

- Place the filter pack 1 foot above the top of the screened interval.
- Place a minimum of 3 feet of bentonite seal above the filter pack.
- Fill the remainder of annular space with a 3 percent to 5 percent bentonite-cement grout.

In no case shall the top of the screen be brought higher than 4 feet bgs because it is difficult to install a reliable annular seal at these shallow depths.

5.6.9 Method-specific Well Installation Techniques

The following sections describe well installation techniques for groundwater monitoring at hazardous waste sites. Sections on troubleshooting common problems encountered when using each technique and potential solutions to the problems are included.

5.6.9.1 HSA

General methods of well installation using the HSA technique are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Mark the well casing near the ground surface to signal to the drillers where the casing should be placed.
- Remember that wells are constructed within the augers as the augers are removed from the ground.
- The diameter of the well casing constructed within an HSA is limited to 4 inches. *Note:* The difference between the I.D. of the HSA and O.D. of the well casing must be at least 4 inches to permit effective placement of filter pack, bentonite seal, and grout.
- Remove the inner rod and hammer quickly, measure the depth of the borehole, and place the well screen and casing quickly into the auger to the desired depth. *Note:* the well screen and casing shall be suspended in hole by the use of a hoisting bail in order to ensure proper depth and plumb construction. This may not be necessary for wells less than 30 feet in depth.
- Prior to adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- The HSA acts as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour filter pack between the inside of the auger and the outside of the well casing.
- While the filter pack material is being poured, incrementally withdraw the auger. The rate of auger withdrawal and filter pack placement shall allow for the top of the filter pack level to be just below the lead auger. In general, the augers should be withdrawn in increments of

2 to 3 feet. *Note:* The level of the top of the filter pack shall be constantly tagged with a measuring tape during emplacement of the filter pack.

- Surge the well to consolidate the filter pack; add more if settlement occurs.
- Emplace bentonite pellets or chips through the HSA. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, pour 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the HSA.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the HSA from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be emplaced from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, the grout may be emplaced directly from the top of the borehole. If the top of the bentonite seal is greater than 10 feet bgs, a tremie tube shall be used to emplace the grout. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing within the HSA.

Avoidance of Locked Well Casing

- Carefully tag the filter pack level and keep it just below the lead auger while the auger is inched up and sand is slowly added.
- Use an auger with a larger I.D.
- Use filter pack materials with a larger grain size.
- Add water of known chemical quality while pouring the sand filter pack. Try this only in cases where the filter pack is very fine.

Solutions for Unlocking Well Casing from Augers

- Gently hold the casing in place while lifting and twisting the auger (do not force).
- Insert the surge block into the casing and gently surge the water column if bridge is below water table.
- Add water between the well and auger if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and then gently blow the bridge away.
- Completely remove the casing and screen, and reinstall the well.
- Never drive the casing out of the auger with a hammer because this will break the casing.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with HSA.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well installation begins. Begin placement of filter pack as soon possible. Add it quickly until over-drilled space is filled.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added shall be recorded on the well installation log and extracted during well development.
- Drill an initial pilot borehole and sample with a 6-inch-diameter auger. The 6-inch auger may be fitted with plastic or metal core catcher on the lead auger, which will allow for soil sampling and prevent sediments from entering augers. After the total sampling depth is reached, the 6-inch auger is removed and 10-inch-diameter augers are substituted to ream out the borehole. Fit the lead auger with a tapered stainless steel plug. At a depth below the desired total depth of the well, use the sampling hammer and center rod to knock out the stainless steel plug. Then complete well installation.

5.6.9.2 DIRECT ROTARY WITH FOAM OR MUD

General well installation techniques using direct rotary with foam or mud are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Place mark on the portion of the well casing near ground surface to identify to the drillers where the casing should be placed. Place centralizers on the well casing and screen as discussed in Section 5.5.2.
- With DRD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. For mud rotary drilling, first thin the mud sufficiently prior to removing the bit and drill pipe from the hole. Thinning the mud allows faster and more accurate placement of the annular materials within the borehole, which balances the density of the borehole fluids so they more closely match the density of the fluids used to install the filter pack and bentonite seal. It also reduces the potential for annular materials to be washed out of the borehole through the tremie.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its stability.
- Suspend the well screen and casing in the hole by the use of hoisting bail in order to ensure proper depth and a plumb construction. This may be unnecessary for wells less than 30 feet in depth. Place the casing and screen in the hole as fast as is safely possible to minimize the time that the borehole stays open.
- Prior to the addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.

- Use a tremie pipe for placement of filter pack, bentonite, and grout. Also emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole.
- Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The level of the top of the filter pack shall be constantly tagged with measuring tape as the filter pack is being emplaced.
- Make the bentonite seal at least 3 feet thick. It should consist of bentonite pellets or chips emplaced through the tremie pipe. Tag the level of the bentonite periodically to ensure accurate placement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be placed directly from the top of the borehole rather than through the tremie pipe.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the tremie pipe from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be placed from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs, and the borehole is not subject to collapse and is not filled with drilling fluid, the grout may be placed directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solution

Controlled pouring of the annular materials is the best solution for bridging. In the case of mud rotary, however, it may be necessary to perform emplacement of the filter pack and bentonite chips or pellets through the borehole without the aid of a tremie pipe. For wells greater than 10 feet deep, obtain the approval of the QA Manager or Technical Director.

5.6.9.3 AIR ROTARY AND AIR ROTARY WITH CASING HAMMER

General well installation techniques using ARD or ARCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure the accurate placement of well casing and screen.
- Remember that with ARD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. With ARCH, the driven casing remains in the ground and is slowly withdrawn as well installation proceeds.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its borehole stability.
- To ensure proper depth and a plumb construction, suspend the well screen and casing in the hole using a hoisting bail. Place the casing and screen in the borehole as fast as is safely possible to minimize the time that the hole stays open, particularly for ARD.

- Before adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- For ARD, use a tremie pipe for placement of filter pack, bentonite, and grout. Emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole. For ARCH, the annular materials can in most cases be placed directly between the driven casing and the well casing. A tremie pipe is advisable if exacting placement is required.
- For ARD, place the tremie pipe within 2 feet of the interval where the filter pack is to be placed. Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The tremie pipe shall be slowly withdrawn during placement.
- Periodically tag the level of the top of the filter pack with measuring tape while the filter pack is being emplaced. Install bentonite in a similar manner.
- For ARCH, pour the filter pack slowly between the well casing and driven casing. The driven casing shall be withdrawn periodically while the filter pack is being emplaced. Withdraw the driven casing in increments no greater than 2 to 3 feet.
- For ARD, emplace bentonite pellets or chips through the tremie pipe to a minimum thickness of 3 feet. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, add 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe. For ARCH, emplace the bentonite between the well casing and the driven casing while the driven casing is being withdrawn.
- Emplace a grout seal through the tremie pipe for the ARD method or through the driven casing for the ARCH method. Emplace the grout from the top of the bentonite seal to within 2 feet of ground surface. The driven casing or tremie pipe shall be withdrawn as the grout is placed. Emplace the grout from bottom to top in one continuous pour following placement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, emplace the grout directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Drilling Problems

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solutions

Controlled pouring of the annular materials is the best solution against bridging.

Heaving Sediment

Fine-grained saturated materials that might cause heaving problems are common in coastal areas. Difficulties caused by heaving sediments might create problems when drilling with ARCH. Heaving sediments cannot be drilled using ARD techniques.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is begun.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Heaving sands may also be controlled by first removing the drill pipe from the hole, and then constructing an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin placement of filter pack as soon as possible and add it quickly until the over-drilled space is filled.

5.6.9.4 DTCH

General well installation techniques using DTCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate depth placement of well casing and screen. Place a mark near the top of the casing to identify to the drillers the proper position to place the casing and screen.
- Like HSA drilling techniques, wells are constructed within the dual tube pipe as the pipe is removed from the ground.
- Prior to setting the casing and screen in the hole, verify total depth of the hole by measuring it and check for surging materials. Suspend the well screen and casing in the hole using a hoisting bail in order to ensure proper depth and plumb construction.
- Prior to addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.
- The inner pipe of the dual tube assembly shall act as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour the filter pack between the inside of the augers and the outside of the well casing to avoid potential bridging of the annular materials. While the filter pack material is being poured, the dual tube pipe shall be incrementally withdrawn. The rate of pipe withdrawal and filter pack emplacement shall allow for the top of the filter pack level to be just below the shoe of the dual tube assembly. The level of the top of the filter pack shall be constantly tagged with measuring tape.
- Use bentonite pellets or chips to construct the well seal, which shall be a minimum of 3-feet thick, and shall also be emplaced through the dual tube assembly. For each foot of bentonite seal installed in an unsaturated completion, 5 gallons of water of known chemical quality shall be poured into the well to hydrate the bentonite. Tag the level of the bentonite periodically to ensure accurate emplacement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe.

- Emplace a grout seal through the dual tube assembly from the top of the bentonite seal to within 2 feet of ground surface. Emplace the grout from bottom to top in one continuous pour immediately following emplacement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs, the grout may be emplaced directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing and dual tube pipe together.

Avoidance of Locked Well Casing

- Tag carefully and always keep the filter pack just below the shoe while inching the dual tube assembly up and slowly adding sand.
- Use a smaller-diameter well casing.
- Use a filter pack with a larger grain size.
- Add water while pouring the sand filter pack. Avoid this unless absolutely necessary.

Solutions for Unlocking Well Casing from Dual Tube Pipe

- Insert a surge block into casing and gently surge the water column if the bridge is below water table.
- Add water between the well and piping if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and gently blow the bridge away.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with DTCH.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion begins.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Remove the drill pipe from the hole, and then construct an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin emplacement of the filter pack as soon as possible, and add it quickly until the over-drilled space is filled.

5.6.10 Well Construction Record Keeping Procedures

A written well completion record (Figure I-C-1-5) detailing the timing, amount of materials, and methods of installation/construction for each step of monitoring well construction shall be prepared during construction of each monitoring well by the FM or designate. Construction records shall be kept in a hard-bound field notebook dedicated to the CTO. An “as-built” drawing illustrating the placement location and amounts of all materials used in construction of each monitoring well shall be prepared in the field at the time of construction. The well construction record shall be filled out with indelible ink. Construction records shall include the date/time and quantities of materials used at each of the following stages of monitoring well construction, including:

- Drilling
    - Drill rig type
    - Drilling method/coring method
    - Drill bit/core barrel diameter (hole diameter)
    - Drill company, driller, helper(s)
    - Field geologist, supervising geologist
    - Dates/times start and finish drilling hole, interval drilling rates
    - Total depth of hole
    - Drilling location, surveyed ground elevation
    - Inclination of hole from horizontal
- Borehole abandonment – type, volume, and surface seal
- Casing material – type
- Casing decontamination – document process and equipment used
- Casing diameter – nominal I.D. of casing
- Screen material
    - Type
    - Top and bottom of section as actually installed
    - Length
    - Slot type, size, shape
    - Type of bottom plug and/or cap used
- Filter pack material
    - Composition and size gradation
    - Manufacturer
    - Actual volume and depth of top and bottom of filter pack
    - Calculated volume versus actual volume used and explanation of discrepancies
- Transition seal

  - Composition and depth of top and bottom of seal
  - Size (or gradation) or material used (e.g., pellets, granulated, or powdered)
  - Time allowed for hydration prior to emplacement of annular grout slurry seal
- Annular slurry seal
  - Date and time of beginning and completion of annular seal
  - Type and actual volume of seal
  - Calculated volume versus actual volume and explanation of discrepancies
  - Set time allowed prior to commencement of additional work
- Surface completion
  - Type of construction
  - Nature of materials used for surface completion
  - Date/time of completion

5.6.11 Well Location

A registered land surveyor shall survey each monitoring well location for exact horizontal location to the nearest 0.5 foot, and exact vertical location to the nearest 0.01 foot, referenced to mean sea level or mean low low water. The vertical elevation shall be surveyed between the two notches cut in the top of the well casing, which is the point from which all water level measurements shall be made. The elevation of the ground or top of the concrete slab adjacent to the monitoring well shall also be surveyed, to the nearest 0.01 foot.

5.7 WELL ABANDONMENT/DESTRUCTION

Once a monitoring well is no longer needed as part of an investigation, or has been damaged to the extent that it cannot be repaired, it is essential that it be properly abandoned. The proper abandonment of a monitoring well ensures that the underlying groundwater supply is protected and preserved. In addition, proper well abandonment eliminates a potential physical hazard and liability. An additional permit and/or inspection may be required for abandonment, depending on state or local regulations.

The standard procedures for the abandonment of a groundwater monitoring well apply to the HSA drilling method. This type of installation was chosen because it is the primary method of abandoning groundwater monitoring wells. For wells abandoned on Guam, the current Guam Environmental Protection Agency Well Abandonment Procedures shall be followed (Attachment I-C-1-1).

The first step in abandoning a groundwater monitoring well is to remove the surface completion from around the top of the well casing. This is normally accomplished using a jackhammer to break the surface cement seal, and then removing the monument or traffic box. When the surface seal and the wellhead cover have been removed, over-drill the well to its total depth using HSAs. Once the total depth of the well has been reached, remove the casing and screen from the borehole. Then completely backfill the borehole with a grout seal. Typically, the grout seal is emplaced as slurry of Portland cement grout, which contains a minimum of 3 to 5 percent bentonite as described in

Section 5.4.5. When mixing the slurry, take care that the bentonite is mixed according to the manufacturer's specifications to ensure the proper consistency.

Emplace the slurry through the HSAs. The rates at which the augers are withdrawn and the slurry is added shall be such that the level of the slurry within the borehole is just below the lead auger. The borehole seal shall extend from the total depth of the borehole to a depth of approximately 1 foot bgs. Then repair the surface to prior conditions and grade.

If the monitoring well casing cannot be pulled or drilled out, perforate the well casing adjacent to the saturated zones so that the annular space and any nearby voids can be filled with sealing material. Fill the perforated well or borehole from the bottom up with an appropriate sealing material, such as neat cement. Inject the neat cement under pressure to force it into the annular space, nearby voids, and filter pack. Apply pressure for a sufficient time to allow the cementing mixture to set. After the cement has hardened, excavate a hole around the well (use a backhoe if necessary) to the depth specified in the Monitoring Well Abandonment Work Plan (WP) and ensure the excavation depth is in accordance with local regulatory agency guidelines (Attachment 1 for *Guam Monitoring Well Abandonment Procedure*) (GEPA 2006). Remove the uppermost portion of the casing, (if still in place), and pour a cement cap on top of the abandoned well, and backfill the remaining portion of the excavation with sealing material. Note, if personnel are required to enter the excavation to remove the upper portion of the casing, then proper sloping and shoring are required as per Section 25, *Excavations* of The Safety and Health Requirements Manual EM 385-1-1 (USACE 2008).

The State of Hawaii Department of Health Hazard Evaluation and Emergency Response must be notified at least 1 week prior to any well abandonment activities conducted in Hawaii (DOH 2009, Section 6.2.5.1). Additionally, an Abandonment of Monitoring Well Summary Report should be prepared using the form presented in Attachment 1-C-1-2. The record should include the following information:

- Well construction information:
  - Date of installation
  - Drilling company
  - Total depth
  - Casing material/length
  - Screen material/length
  - Annular material
- General abandonment information:
  - Drilling firm (contact, mailing address, and phone number).
  - Consulting firm (contact, mailing address, and phone number).
- Well abandonment information
  - Date of abandonment
  - Reason for abandonment

- Details of how the casing/screen was removed drilled out or perforated.
- Sealing material (weight/volume/bags/mix ratio)

5.8 VAPOR EXTRACTION/MONITORING WELLS

Vapor extraction/monitoring wells have most of the same design and installation considerations and procedures as groundwater-monitoring wells, with the exception that they are screened in the unsaturated zone. Vapor extraction/monitoring wells generally shall not be screened over an interval greater than 20 feet and shall not be screened over two or more lithologies that have air permeabilities that differ by more than one order of magnitude. Vapor extraction/monitoring wells shall be installed using drilling techniques that do not require drilling fluids other than filtered air. Vapor monitoring wells may have casing I.D.s of 2 inches or less while extraction wells shall generally have casing I.D.s of at least 4 inches. The design of vapor extraction/monitoring wells is dependent upon many site-specific factors, such as the depth of contamination, soil conditions, geology, and depth to groundwater. As a result, specifics related to the design of these wells shall be included in the CTO WP, field sampling plan, or plans and specifications.

5.9 DRIVE POINTS

An alternative to conventional monitoring well construction is, under limited conditions, the use of drive points. These consist of slotted steel pipe that is pushed, hammered, or hydraulically jetted into the ground. A filter pack is not constructed around the screen, so the width of the screen openings must be sufficiently small to prevent the passage of significant quantities of sediment into the well during the withdrawal of water for sampling. In some instances, the drive points are used only as piezometers.

Drive points are commonly used in hazardous waste investigations to sample ambient soil gases in the vadose zone. It is often possible to extend the drive point below the water table to collect water samples. In some instances, permits may be required because the drive points are considered in some jurisdictions to be equivalent to a temporary monitoring well.

5.10 DISCRETE DEPTH GROUNDWATER SAMPLING

Another alternative to conventional monitoring well construction is the use of a discrete groundwater sampling device such as a Hydropunch. The Hydropunch tool can be used in conjunction with a standard drill rig, a cone penetrometer rig, or possibly a vehicle capable of driving vapor probes to sample groundwater and non-aqueous phase liquid in unconsolidated formations. The Hydropunch tool is constructed of a stainless steel drive point, a perforated section of Teflon pipe for a sample intake, and a stainless steel sample chamber. The tool is 55.5 inches long, 2 inches in O.D., and weighs approximately 24 pounds.

Ideally, a standard HSA drilling rig is used to drill a pilot hole to a depth just above the desired sampling depth. The Hydropunch tool is then hydraulically pushed or driven 4 to 5 feet through the saturated zone at each sampling location. As the tool is advanced, the sample intake screen remains pristine within the watertight stainless steel chamber. When the desired sampling interval is reached, the steel sampling chamber is unscrewed and withdrawn 1 foot to several feet, depending on how long a sampling interval is needed. This exposes the intake screen to the groundwater. Under hydrostatic pressure, groundwater flows through the intake screen and fills the sample chamber, without aeration or agitation occurring. The drive cone, which is attached to the base of the screen, will remain in place by soil friction.

The pointed shape of the sampler and its smooth exterior surface prevent downward transport of surrounding soil and groundwater as the tool is advanced. Once in place, the intake screen will be sealed from groundwater above and below the interval being sampled, because the exterior of the Hydropunch tool is flush against the surrounding soil wall. Additionally, as the tool is advanced, the sample intake screen is retained within the steel watertight sample chamber.

A stainless steel or Teflon bailer with a bottom check valve is lowered into the sample chamber to collect the groundwater sample. Groundwater is then decanted at ground surface from the bailer into the appropriate sample containers.

6. Records

Monitoring well location, design, and construction shall be recorded in the field notebook for the CTO and on a well completion record form (Figure I-C-1-5). The field operations manager should provide a copy of this form to the CTO Manager for the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM) 2010. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. D5092-04^{e1}(Reapproved 2010). West Conshohocken, PA.

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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———.2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Guam Environmental Protection Agency (GEPA). 2006. *Well Abandonment Procedure*. Water Resources Management Program.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-5, Utility Clearance.

Procedure I-B-1, Soil Sampling.

Procedure I-B-5, Surface Water Sampling.

Procedure I-F, Equipment Decontamination.

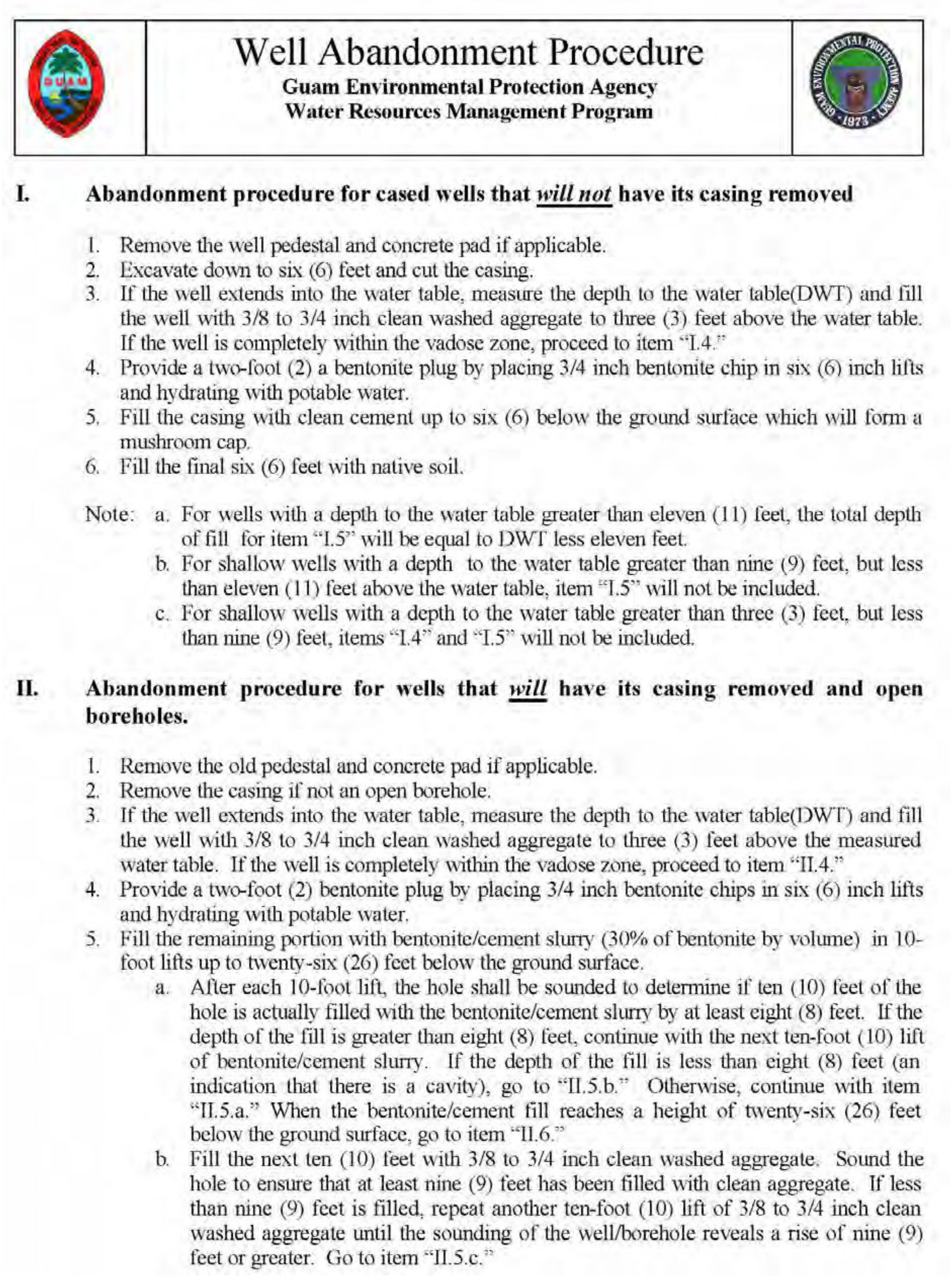
9. Attachments

Attachment I-C-1-1, Guam Monitoring Well Abandonment Procedure

Attachment I-C-1-2, DOH Abandonment of Monitoring Well Summary Report Form

Attachment I-C-1-1

Guam Well Abandonment Procedure



Well Abandonment Procedure

Guam Environmental Protection Agency
Water Resources Management Program

I. Abandonment procedure for cased wells that ***will not*** have its casing removed

1. Remove the well pedestal and concrete pad if applicable.
2. Excavate down to six (6) feet and cut the casing.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the water table. If the well is completely within the vadose zone, proceed to item "I.4."
4. Provide a two-foot (2) a bentonite plug by placing 3/4 inch bentonite chip in six (6) inch lifts and hydrating with potable water.
5. Fill the casing with clean cement up to six (6) below the ground surface which will form a mushroom cap.
6. Fill the final six (6) feet with native soil.

Note: a. For wells with a depth to the water table greater than eleven (11) feet, the total depth of fill for item "I.5" will be equal to DWT less eleven feet.
b. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, item "I.5" will not be included.
c. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "I.4" and "I.5" will not be included.

II. Abandonment procedure for wells that ***will*** have its casing removed and open boreholes.

1. Remove the old pedestal and concrete pad if applicable.
2. Remove the casing if not an open borehole.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the measured water table. If the well is completely within the vadose zone, proceed to item "II.4."
4. Provide a two-foot (2) bentonite plug by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water.
5. Fill the remaining portion with bentonite/cement slurry (30% of bentonite by volume) in 10-foot lifts up to twenty-six (26) feet below the ground surface.
    a. After each 10-foot lift, the hole shall be sounded to determine if ten (10) feet of the hole is actually filled with the bentonite/cement slurry by at least eight (8) feet. If the depth of the fill is greater than eight (8) feet, continue with the next ten-foot (10) lift of bentonite/cement slurry. If the depth of the fill is less than eight (8) feet (an indication that there is a cavity), go to "II.5.b." Otherwise, continue with item "II.5.a." When the bentonite/cement fill reaches a height of twenty-six (26) feet below the ground surface, go to item "II.6."
    b. Fill the next ten (10) feet with 3/8 to 3/4 inch clean washed aggregate. Sound the hole to ensure that at least nine (9) feet has been filled with clean aggregate. If less than nine (9) feet is filled, repeat another ten-foot (10) lift of 3/8 to 3/4 inch clean washed aggregate until the sounding of the well/borehole reveals a rise of nine (9) feet or greater. Go to item "II.5.c."

   c. Provide a two-foot (2) bentonite plug above the clean aggregate by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water. Continue with item "II.5.a."

6. Fill the next twenty (20) feet above the bentonite/cement fill with neat cement.
7. The remaining six (6) feet shall be filled with native soil.

Note:
   a. For wells with a depth to the water table greater than thirty-one (31) feet, the total depth of fill for item "II.5" will be equal to DWT less thirty-one (31) feet.
   b. For shallow wells with a depth to the water table greater than eleven (11) feet, but less than thirty-one (31) feet above the water table, item "II.5" will not be included.
   c. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, items "II.5" and "II.6" will not be included.
   d. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "II.4", "II.5" and "II.6" will not be included.

General Notes:

a. The driller shall submit a well abandonment plan following the above procedure to Guam EPA for review/approval.
b. The driller shall notify Guam EPA administrator 48 hours prior to starting date of the the approved abandonment plan.
c. All above-ground materials shall be removed from the well site and disposed in a manner that conforms to the Guam EPA's solid waste regulations.
d. If a well is in an area that is covered with asphalt or concrete that is not to be removed (such as a parking lot or a driveway/street), the native soil fill may be excluded and the well may be filled to the top with neat cement and then covered with new asphalt or concrete.

Attachment I-C-1-2

DOH Abandonment of Monitoring Well Summary Report Form

STATE OF HAWAII 1959

Abandonment of Monitoring Well Summary Report

___________________ (Monitoring Well ID)

Submit form within 30 days of well abandonment or within 90 days if included in a site closure, monitoring, or investigation report. In addition, submit copies of the original boring log and well construction diagram for the monitoring well, a site map showing the location of the abandoned monitoring well, and the disposal documentation for wastes generated during the abandonment process. Submit all documentation to: Hawaii Department of Health, Hazard Evaluation and Emergency Response Office, Attention: SDAR, 919 Ala Moana Blvd, Rm. 206, Honolulu Hawaii 96814.

Location Information	**Owner Information**
Facility Name:	Well Owner:
Facility Address:	Contact Person:
	Mailing Address:
Latitude:	
Longitude:	Phone Number: Fax Number:
TMK:	Land Owner:
Location Description:	Contact Person:
	Mailing Address:
Monitoring Well Location Map Attached: Y N	Phone Number: Fax Number:

Well Construction Information

Date of Installation:	Casing Material: Casing Diameter:
Drilling Company:	Casing Length: Casing Depth:
Total Depth:	Screen Material: Slot Size:
Depth to Water:	Screen Length: Screen Depth:
Was the Well Set in an Aquifer that is a Current or Potential	Annular Material: Depth:
Drinking Water Source: Y N	Annular Material: Depth:
Boring Log/Well Construction Diagram Attached: Y N	Annular Material: Depth:

General Abandonment Information

Drilling Firm:	Consulting Firm:
Contact Person:	Contact Person:
Mailing Address:	Mailing Address:
Phone Number: Fax Number:	Phone Number: Fax Number:

Well Abandonment Information

Date of Abandonment:	Sealing Material: Depth:
Reason for Abandonment:	Volume/Weight/Bags Mixing Ratio:
Casing/Screen Removed: Y N	Sealing Material: Depth:
If Yes, was annular material removed?: Y N	Volume/Weight/Bags Mixing Ratio:
If No, was casing cut off below the surface?: Y N	Method of Sealing Material Placement:

Comments:

Driller's Signature: Date:

Consultant's Signature: Date:

Version: September 2005

Monitoring Well Development

1. Purpose

This section describes the standard operating procedures for monitoring well development to be used by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these monitoring well development procedures are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well development shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedure

5.1 INTRODUCTION

Well development procedures are crucial in preparing a well for sampling. They enhance the flow of groundwater from the formation into the well and remove the clay, silt, and other fines from the formation so that produced water will not be turbid or contain suspended matter that can interfere with chemical analyses. A monitoring well should be a “transparent” window into the aquifer from which samples can be collected that are truly representative of the quality of water that is moving through the formation.

The goal of well development is to restore the area adjacent to a well to its natural condition by correcting damage to the formation during the drilling process. Well development shall accomplish the following tasks:

- Remove a filter cake or any drilling fluid within the borehole that invades the formation.
- Remove fine-grained material from the filter pack.
- Increase the porosity and permeability of the native formation immediately adjacent to the filter pack.

Well development shall not occur until 24 hours after the completion of well installation to allow the annular seal to fully set up.

5.2 FACTORS AFFECTING MONITORING WELL DEVELOPMENT

5.2.1 Type of Geologic Materials

Different types of geologic materials are developed more effectively by using certain development methods. Where permeability is greater, water moves more easily into and out of the formation and development is accomplished more quickly. Highly stratified deposits are effectively developed by methods that concentrate on distinct portions of the formation. If development is performed unevenly, a groundwater sample will likely be more representative of the permeable zones. In uniform deposits, development methods that apply powerful surging forces over the entire screened interval will produce satisfactory results.

5.2.2 Design and Completion of the Well

Because the filter pack reduces the amount of energy reaching the borehole wall, it must be as thin as possible if the development procedures are to be effective in removing fine particulate material from the interface between the filter pack and natural formation. Conversely, the filter pack must be thick enough to ensure a good distribution of the filter pack material during emplacement. The general rule is that filter pack material must be at least 2 inches thick.

The screen slot size must be appropriate for the geologic material and filter pack material in order for development to be effective. If slot size is too large, the removal of too much sediment may cause settlement of overlying materials and sediment accumulation in the casing. When screen openings are too small, full development may not be possible and well yield will be below the potential of the formation. Additionally, incomplete development coupled with a narrow slot size can lead to blockage of the screen openings.

5.2.3 Drilling Method

The drilling method influences development procedure. Typical problems associated with specific drilling methods include the following:

- If a mud rotary method is used, mud cake builds up on the borehole wall and must be removed during the development process.

- If drilling fluid additives have been used, the development process must include an attempt to remove all fluids that have infiltrated into the native formation.
- If driven casing or hollow-stem auger methods have been used, the interface between the casing or auger flights and the natural formation may have been smeared with fine particulate matter that must be removed during the development process.
- If an air rotary method has been used in rock formations, fine particulate matter is likely to build up on the borehole walls and may plug pore spaces, bedding planes, and other permeable zones. These openings must be restored during the development process.

5.3 PREPARATION

In preparing for monitoring well development, development logs for any other monitoring wells in the vicinity should be reviewed to determine the general permeability of the water-bearing formation and the appropriate development method.

Depth to groundwater and information from the well construction log should be used in calculating the required quantity of water to be removed. The distance between the equilibrated water level and the bottom of the screen is the saturated section. The saturated section (feet) multiplied by the unit well volume per foot (gallons/linear foot) equals the gallons required to remove one total well volume of water. The unit well volume is the sum of the casing volume and the filter pack pore volume, both of which depend upon casing and borehole diameter and the porosity of the filter pack material. Well volume can be calculated using Table I-C-2-1, Table I-C-2-2, or Table 1-C-2-3.

Table I-C-2-1: Casing Volume*

Casing Diameter (inches)	Volume (gallon/linear foot)
2	0.16
4	0.65
6	1.47

Table I-C-2-2: Filter Pack Pore Volume

Casing Diameter (inches)	Borehole Diameter (inches)	Volume [a] (gallon/linear foot)
2	6	0.52
2	8	0.98
4	10	1.37
4	12	2.09
6	12	1.76

* The above two volumes must be added together to obtain one unit well volume.

[a] Assumes a porosity of 40% for filter pack.

Table I-C-2-3: Well Volume Calculation

HOLE DIAMETER d_h =

WELL CASING
INSIDE DIAMETER d_wID =

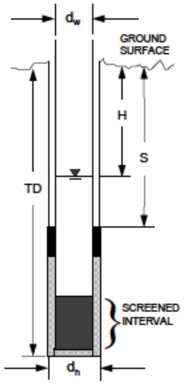
OUTSIDE DIAMETER d_wOD = ______

DEPTH TO:
WATER LEVEL H =

BASE OF SEAL S = ______

BASE OF WELL TD =

EST. FILTER PACK POROSITY P = ______



WELL VOLUME CALCULATION :

$$\text{CASING VOLUME} = V_c = \Pi\left(\frac{d_w\text{ID}}{2}\right)^2(\text{TD} - \text{H}) = 3.14\left(\frac{\_\_\_}{2}\right)^2(\_\_\_\_ - \_\_\_\_) = \_\_\_\_\_\_$$

$$\text{FILTER PACK PORE VOLUME} = V_f = \Pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_w\text{OD}}{2}\right)^2\right](\text{TD} - (\text{S or H}^*)(\text{P}) = \_\_\_\_\_\_$$

$(^*\text{if } S > H, \text{use } S; \text{if } S < H, \text{use } H)$

$$= 3.14\left[\left(\frac{\_\_\_}{2}\right)^2 - \left(\frac{\_\_\_}{2}\right)^2\right](\_\_\_\_ - \_\_\_\_)(\_\_\_\_) = \_\_\_\_\_\_$$

$$\text{TOTAL WELL VOLUME} = \text{VT} = \text{Vc} + \text{Vf} = \_\_\_\_ + \_\_\_\_ = \_\_\_\_\_\_ \text{ ft.}^3 \times 7.48 = \_\_\_\_\_\_ \text{ gal.}$$

5.4 DECONTAMINATION

The purpose of decontamination of development equipment is to prevent cross-contamination between monitoring wells. Use disposable equipment where appropriate. Use a steam-cleaner, if available, to decontaminate development equipment. Clean the equipment away from the monitoring well in such a fashion that decontamination effluent can be intercepted and drummed.

A triple rinse decontamination procedure is acceptable for equipment, such as bailers, or if access to a steam cleaner is not possible (Procedure I-F, *Equipment Decontamination*).

During well development, place visqueen around the well to prevent contamination at ground surface. Properly dispose of this sheeting after each use.

5.5 WELL DEVELOPMENT MONITORING

Throughout the well development process, maintain a development record using the form presented in Attachment I-C-2-1. The record should include the following information:

- General:
  - Project name and number
  - Well name/number and location
  - Date, time, and weather conditions
  - Names of personnel involved
- Development volume:
  - Initial and final water level
  - Casing total depth and diameter
  - Borehole diameter
  - Casing volume, filter pack pore volume, total well volume
  - Volume of water to be evacuated
  - Method and rate of removal
  - Appearance of water before and after development
- Monitoring data for each sample point:
  - Date, time, elapsed time
  - Cumulative gallons removed, removal method, removal rate
  - Temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, turbidity, dissolved oxygen, redox potential, and salinity

Part of the well development procedure shall consist of acquisition and analysis of water samples at appropriate intervals considering the total quantity of water to be removed. Measure conductivity, pH, temperature, dissolved oxygen, redox potential, turbidity, and salinity in each sample using a multi-parameter meter and flow-through cell. Collect readings on a periodic basis (approximately every 3 to 5 minutes) during development and obtain at least one reading after removal of each well volume. At the time each sample is analyzed, record the cumulative water removed, the time, the time elapsed during development, and calculated flow rate. Continue development until at least 3 borehole volumes have been removed, turbidity stabilizes at or below 5 nephelometric turbidity units, and three successive readings of the parameters have stabilized (values within 10 percent of each other). If stabilization has not been attained, if turbidity remains high, or if the well does not readily yield water, allow the water level in the well to recover, conduct an additional 15 minutes of mechanical surging and/or bailing, then continue development until stabilization can be achieved or for a reasonable time.

Section 5.7 describes well development in special situations, such as low yield formations and 2-inch wells.

5.6 METHODS OF MONITORING WELL DEVELOPMENT

The methods available for the development of monitoring wells have been inherited from production well practices. Methods include: (1) mechanical surging with a surge block or swab, and (2) surge pumping. Development methods using air or jetting of water into the well are generally inappropriate for development of monitoring wells due to the potential for affecting water quality.

Containerize and appropriately label all development water (unless it is permissible to discharge it on site). All development efforts must utilize mechanical surging or surge pumping, followed by bailing or groundwater removal with a pump. More detailed descriptions of appropriate development methods are presented below.

5.6.1 Mechanical Surging and Bailing

For mechanical surging and bailing, a surge block or swab is operated either manually or by a drill rig. The surge block or swab should be vented and be of sufficient weight to free-fall through the water in the well and create a vigorous outward surge. The equipment lifting the tool must be strong enough to extract it rapidly. A bailer is then used to remove fine-grained sediment and groundwater from the well.

Procedures:

1. Properly decontaminate all equipment entering the well.
2. Record the static water level and the total well depth.
3. Lower the surge block or swab to the top of the screened interval.
4. Operate in a pumping action with a typical stroke of approximately 3 feet.
5. Gradually work the surging downward through the screened interval during each cycle.
6. Surge for approximately 10 to 15 minutes per cycle.
7. Remove the surge block and attach the bailer in its place.
8. Bail to remove fines loosened by surging until the water appears clear.

9. Repeat the cycle of surging and bailing at least three times or until turbidity is reduced and stabilization of water quality parameters occurs.
10. The surging shall initially be gentle and the energy of the action should gradually increase during the development process.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.
+ It affects the entire screened interval.
+ It effectively removes fines from the formation and the filter pack.
– It might cause upward movement of water in the filter pack that could disrupt the seal.
– Potential exists for damaging a screen with a tight-fitting surge block or with long surge strokes.

5.6.2 Surge Pumping

Procedures:

1. Properly decontaminate all equipment entering the well.
2. Record the static water level and the total well depth.
3. Lower a submersible pump or airlift pump without a check valve to a depth within 1 to 2 feet of the bottom of the screened section.
4. Start pumping and increase discharge rate to maximum capacity (overpumping), causing rapid drawdown of water in the well.
5. Periodically stop and start the pump, allowing the water in the drop pipe to fall back into the well and surge the formation (backwashing), thus loosening particulates.
6. The pump intake shall be moved up the screened interval in increments appropriate to the total screen length.
7. At each pump position, the well shall be pumped, overpumped, and backwashed alternately until satisfactory development has been attained as demonstrated by reduction in turbidity and stabilization of water quality parameters.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.
+ It effectively removes fines from the formation and filter pack.
– The pump position or suction line must be changed to cover the entire screen length.

- Submersible pumps suitable to perform these operations may not be available for small diameter (1 inch or less) monitoring wells.
- It is not possible to remove sediment from the well unless particle size is small enough to move through the pump.

For additional information on well development, consult the references included in Section 8 of this procedure.

5.7 SPECIAL SITUATIONS

5.7.1 Development of Low Yield Wells

Development procedures for monitoring wells in low-yield (<0.25 gallons per minute), water-bearing zones are somewhat limited. Due to the low hydraulic conductivity of the materials, surging of water in and out of the well casing is difficult. Also, the entry rate of water is inadequate to remove fines from the well bore and the gravel pack when the well is pumped. Additionally, the process may be lengthy because the well can be easily pumped dry and the water level is very slow to recover.

Follow the procedures for mechanical surging and bailing for low yield wells. During surging and bailing, wells in low yield formations should be drawn down to total depth twice, if possible. Development can be terminated, however, if the well does not exhibit 80 percent recovery after 3 hours.

5.7.2 Development of 2-inch Wells

It is easier to develop monitoring wells that are large in diameter than small diameter wells. Mechanical surging or bailing techniques that are effective in large diameter wells are much less effective when used in wells 2 inches or less in diameter. Mechanical surge blocks and bailers have a high potential for damaging a small diameter well. As a result, the CTO Manager shall obtain approval from the QA Manager or Technical Director prior to installing groundwater monitoring wells with inside diameters of 2 inches or less.

Develop two-inch or smaller diameter wells by surging with a specially designed, hand-operated surge block or by pumping with a bladder or airlift pump. Information related to development of wells 2 inches or less in diameter shall be included in the CTO work plan.

6. Records

Well development information should be documented in indelible ink on well development monitoring forms (Attachment I-C-2-1). Copies of this information shall be sent to the CTO Manager and to the project files. The CTO Manager shall review all well development logs on a minimum monthly basis.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-F, *Equipment Decontamination.*

9. Attachments

Attachment I-C-2-1: Well Development Record

Attachment I-C-2-1
Well Development Record

WELL DEVELOPMENT LOG

PROJECT	**WELL ID**	**SITE**	**PREPARED BY**

METHOD
OVERPUMPAGE ☐
BAILER ☐
SURGE BLOCK ☐
AIR LIFT ☐
OTHER __________

INITIAL WATER LEVEL:
INITIAL TOTAL DEPTH:

FINAL WATER LEVEL:
FINAL TOTAL DEPTH:

REMARKS:

*CAPACITY OF CASING (GALLONS/LINEAR FOOT)

1” - 0.012
2” - 0.16
4” - 0.65
6” - 0.1.47

*VOLUME BETWEEN CASING AND HOLE (GALLONS/LINEAR FOOT) (ASSUMING 40% POROSITY)

1” CASING AND 2” HOLE - 0.013
2” CASING AND 6” HOLE - 0.52
2” CASING AND 8” HOLE - 0.98
4” CASING AND 10” HOLE - 1.37
4” CASING AND 12” HOLE - 2.09

*The two volumes for the saturated portion of the well must be added together to obtain one unit well volume.

DEVELOPMENT LOG:					**CUMULATIVE WATER REMOVED**	**WATER QUALITY**							**COMMENTS**
DATE	**TIME**	**METHOD**	**ELAPSED TIME**	**FLOW RATE (gpm)**	**GALLONS**	**pH**	**TEMP (°C)**	**SP. COND (mS/cm)**	**DO (mg/L)**	**ORP (mV)**	**TURBIDITY (ntu)**	**SALINITY (ppt)**	

DO	dissolved oxygen
ORP	oxidation-reduction potential

Monitoring Well Sampling

1. Purpose

This standard operating procedure describes the monitoring well sampling procedures to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard groundwater sampling activities are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager or designee shall review all groundwater sampling forms on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

Minimum qualifications for sampling personnel require that one individual on the field team shall have a minimum of 1 year experience with sampling monitoring wells.

The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the QA Manager or Technical Director and then documented in the field logbook and associated report or equivalent document.

5. Procedures

5.1 PURPOSE

This procedure establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples of aquifer conditions with as little alteration of water chemistry as possible.

5.2 PREPARATION

5.2.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well history data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records (including depth of screened interval), well development methods, previous analytical results, presence of an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling, and water level measurement collection shall proceed from the least contaminated to the most contaminated as indicated in previous analytical results. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

5.2.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of QA/quality control (QC) samples to be collected (Procedure III-B, *Field QC Samples [Water, Soil]*), as well as the type and volume of sample preservatives, the number of sample containers (e.g., coolers), and the quantity of ice or other chilling materials. The sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. Document the analytical requirements for groundwater analysis in the project-specific work plan.

5.3 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling procedures at a site shall include: (1) measurement of well depth to groundwater; (2) assessment of the presence or absence of an immiscible phase; (3) assessment of purge parameter stabilization; (4) purging of static water within the well and well bore; and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events.

5.3.1 Measurement of Static Water Level Elevation

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Mark each well with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed.

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. Measure water levels twice in quick succession and record each measurement. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Measure the water level in each well immediately prior to purging the well.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

5.3.2 Decontamination of Equipment

Establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled and far enough from potential contaminant sources to avoid contamination of clean equipment. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in Procedure I-F, *Equipment Decontamination*.

Decontaminate each piece of equipment prior to entering the well. Also conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without onsite decontamination.

5.3.3 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL, as necessary, before the well is evacuated for conventional sampling:

1. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a photoionization detector or an organic vapor analyzer (flame ionization detector), and record the measurements.

2. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
3. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
4. In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error, and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water-table contour maps until they are corrected for depression by the product.

If the well contains an immiscible phase, it may be desirable to sample this phase separately. Sections 5.3.5.1 and 5.3.5.2 present immiscible phase sampling procedures. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the CTO Manager and QA Manager or Technical Director if this situation is encountered.

5.3.4 Purging Equipment and Use

The water present in a well prior to sampling may not be representative of *in situ* groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the investigation-derived waste (IDW) handling procedures in Procedure I-A-6, *Investigation-Derived Waste Management*.

Purging shall be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. Environmental Protection Agency (EPA) (EPA 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/min. The EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. The EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. The goal is minimal drawdown (less than 0.1 meter) during purging (EPA 1996). The amount of drawdown during purging should be recorded at the same time the other water parameters are measured. Also, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells shall not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable.

In high yield wells (wells that exhibit 80 percent recovery in less than 2 hours), purging shall be conducted at relatively low flow rates and shall remove water from the entire screened interval of the well to ensure that fresh water from the formation is present throughout the entire saturated interval. In general, place the intake of the purge pump 2 to 3 feet below the air-water interface within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified.

Low yield wells (those that exhibit less than 80 percent recovery in less than 2 hours) require one borehole volume of water to be removed. Allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis (approximately every 5 minutes) during well evacuation and analyze them in the field preferably using a multi-parameter meter and flow-through cell for temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), turbidity, salinity, and total dissolved solids (TDS). Take at least five readings during the purging process. These parameters are measured to demonstrate that the natural character of the formation water has been pumped into the well. Purging shall be considered complete when three consecutive sets of field parameter measurements stabilize within approximately 10 percent (EPA 2006). However, suggested ranges are ±0.2 degrees Celsius for temperature, ±0.1 standard units for pH, ±3 percent for specific conductance, ±10 percent for DO, and ±10 millivolts for redox potential (ASTM 2001). This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process including drawdown, into a groundwater sampling log (Figure I-C-3-1). Complete all blanks on this field log during sampling.

In cases where an LNAPL has been detected in the monitoring well, insert a stilling tube of a minimum diameter of 2 inches into the well prior to well purging. The stilling tube shall be composed of a material that meets the performance guidelines for sampling devices. Insert the stilling tube into the well to a depth that allows groundwater from the screened interval to be purged and sampled, but that is below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, insert the stilling tube into the well in a manner that prevents the LNAPL from entering the stilling tube. However, sampling groundwater beneath a NAPL layer is not generally recommended due to the fact that the interval with residual NAPL saturation is often unknown and the NAPL can be mobilized into the well from intervals below the water table.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. Slowly lower the stilling tube into the well to the appropriate depth and then attach it firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. Firmly fasten the membrane or material that is used to cover the end of the stilling tube so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off of the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required, based on the site-specific situation. Thoroughly decontaminate stilling tubes prior to each use. Collect groundwater removed during purging, and store it on site until its disposition is determined based upon laboratory analytical results. Storage shall be in secured containers, such as U.S. Department of Transportation-approved drums. Label containers of purge water with the standard NAVFAC Pacific ER Program IDW label.

The following paragraphs list available purging equipment and methods for their use.

5.3.4.1 BAILERS AND PUMPS

Submersible Pump: A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling groundwater for volatile, semivolatile, and non-volatile constituents. For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to over stressing of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to the placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to keep water from flowing back down the drop pipe into the well. Place the pump intake approximately 2 to 3 feet below the air-water interface within the well and maintain it in that position during purging. Additionally, when pulling the pump out of the well subsequent to purging, take care to avoid dumping water within the drop pipe and pump stages back into the well.

Bladder Pump: A stainless steel and/or Teflon bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Additionally, the bladder pump can be used for purging and obtaining groundwater samples overlain by a LNAPL layer as long as care is taken not to draw the product layer into the bladder pump. Use of the bladder pump is most effective in low to moderate yield wells.

Either a battery powered compressor, compressed dry nitrogen, or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use. Once purging is complete, collect the samples directly from the bladder pump.

Centrifugal or Diaphragm Pump: A centrifugal, or diaphragm, pump may be used to purge a well if the water level is within 20 feet of ground surface. A new, or properly decontaminated, hose is lowered into the well and water withdrawn at a rate that does not cause excessive well drawdown.

GROUNDWATER SAMPLING LOG

WELL NO. ____________ LOCATION: ____________ PROJECT NO. ____________

DATE: TIME: ____________ CLIMATIC CONDITIONS: ____________

TIDAL CONDITIONS: Rising ☐ Falling ☐ HIGH TIDE: LOW TIDE: CURRENT TIDE:

STATIC WATER LEVEL (FT.) and TIME: ____________ TOTAL DEPTH (FT.): ____________

WELL PURGING: LENGTH OF SATURATED ZONE: ____________ LINEAR FT.

a VOLUME OF WATER TO BE EVACUATED: ________ GALS. (Gals/Linear ft. X linear feet of saturation X 3-casing volumes)

METHOD OF REMOVAL: ____________ PUMPING RATE: ________ mL/min

WELL PURGE DATA:

DATE/ TIME	DTW	GALLONS REMOVED	TDS (g/L)	pH	SP. COND. (mS/cm)	D.O. (mg/L)	TURB. (NTU)	TEMP. (°C)	ORP (mV)	SAL (ppt)

SAMPLE WITHDRAWAL METHOD: ____________

APPEARANCE OF SAMPLE: COLOR: ____________

SEDIMENT: ____________

OTHER: ____________

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES ____________

NUMBER AND TYPES OF SAMPLE CONTAINERS USED: ____________

SAMPLE IDENTIFICATION NUMBER(S) ____________

DECONTAMINATION PROCEDURES: ____________

NOTES: ____________

SAMPLED BY: ____________

SAMPLES DELIVERED TO: ____________ TRANSPORTER: ____________

DATE: ____________ TIME: ____________

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2"-0.16•4"-0.65•6"-1.47•8"-2.61•10"-4.08•12"-5.87

Figure I-C-3-1: Groundwater Sampling Log

Place the hose bottom approximately 2 to 3 feet below the air-water interface and maintain it in that position during purging.

Air Lift Pump: Airlift pumps are not appropriate for purging or sampling.

Bailer: Avoid using a bailer to purge a well because it can result in aeration of the water in the well and possibly cause excessive purge rates. If a bailer must be used, decontaminate the bailer, bailer wire, and reel as described in Section 5.3.2 prior to its use. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well. The QA Manager or Technical Director shall approve use of bailers for purging monitoring wells in advance.

5.3.5 Monitoring Well Sampling Methodologies

5.3.5.1 SAMPLING LIGHT, NON-AQUEOUS PHASE LIQUIDS (LNAPL)

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with the LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well, and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. When using bailers to collect LNAPL samples for inorganic analyses, the bailer shall be composed of fluorocarbon resin. Bailers used to collect LNAPL samples for organic analyses shall be constructed of stainless steel. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

5.3.5.2 SAMPLING DENSE, NON-AQUEOUS PHASE LIQUIDS (DNAPL)

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

5.3.5.3 GROUNDWATER SAMPLING METHODOLOGY

The well shall be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton is not acceptable. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or single strand stainless steel wire) shall be used to raise and lower the bailer. Generally, bladder and submersible pumps are acceptable sampling devices for all analytical parameters. Dedicated equipment is highly recommended for all sampling programs. The following text describes sampling methods utilizing submersible pumps, bladder pumps, and bailers.

Submersible Pumps: When operated under low-flow rate conditions (100 to 300 milliliters [mL]/minute or less), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 300 mL/minute may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

Bladder Pumps: A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

Most models of bladder pumps can be operated with a battery powered compressor and control box. The compressor can be powered with either a rechargeable battery pack (provided with the compressor), by running directly off of a vehicle battery (via alligator clips), or by plugging into the vehicle’s direct current connector (cigarette lighter receptacle). When using a vehicle to power a compressor, several precautions should be taken. First, position the vehicle downwind of the well. Second, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the compression hose from the well cap to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs so as to discharge water at a flow rate (purge rate) that minimizes drawdown in the well, usually around 100 to 300 mL/minute. The compressor should not be set as to discharge the water as hard as possible. The optimal setting is one that produces the required purge rate per minute (not per purge cycle) while maintaining a minimal drawdown.

Prior to sampling volatiles constituents, turn off the vehicle engine, and obtain a flow rate of 100 mL/minute so as not to cause fluctuation in pH, pH-sensitive analytes, the loss of volatile constituents, or draw down of the groundwater table. If necessary (when sampling wells that require a large sample volume) the vehicle engine may be turned back on after sampling volatile constituents. Higher flow rates (100 to 300 mL/minute) can be used once the samples for the analysis of volatile components have been collected, but should not allow for increased draw down in the well. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, DO, specific conductivity, and reduction/oxidation (redox).

For those samples requiring filtration, it is recommended to use in-line high capacity filters after all nonfiltered samples have been collected.

Bailers: A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The QA Manager or Technical Director must approve the use of bailers for groundwater sampling in advance.

Thoroughly decontaminate the bailer before being lowering it into the well if it is not a disposable bailer sealed in plastic. Collect two to three rinse samples and discharge them prior to acquisition of the actual sample. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

The preferred alternative when using bailers for sampling is to use disposable Teflon bailers equipped with bottom-discharging devices. Use of disposable bailers reduces decontamination time and limits the potential for cross-contamination.

Passive Sampling: Passive samplers include passive diffusion bags, HydraSleeve, Snap Sampler, Gore Sorbers, and rigid porous polyethylene samplers. Passive samplers generate minimal waste and purge water, if any. Passive samplers depend on ambient equilibrium with formation water. These are relatively inexpensive, simple to deploy and work well for low-yield wells. However, passive samplers have volume and or analyte limitations and may require consideration of contaminant stratification. Passive samplers should be handled in accordance with the manufacturer's instructions, Army guidance (USACE 2002), or ITRC guidance (ITRC 2007).

5.3.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, preserve samples. The EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846* (EPA 2007), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field team may add preservatives in the field. Sample containers should be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody*.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the CTO-specific work plan. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. An analytical laboratory shall provide these vials, preferably by the laboratory that will perform the analysis. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the investigator shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles form most of the time. Field logs and laboratory analysis reports shall note any headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

5.3.6.1 SPECIAL HANDLING CONSIDERATIONS

Samples requiring analysis for organics shall not be filtered. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples shall be handled and analyzed in the same manner as VOC samples.

Obtain groundwater samples to be analyzed for metals sequentially. One sample shall be obtained directly from the pump and be unfiltered. The second sample shall be filtered through a 0.45-micron membrane in-line filter. Both filtered and unfiltered samples shall be transferred to a container, preserved with nitric acid to a pH less than 2, and analyzed for dissolved metals. Remember to include a filter blank for each lot of filters used and always record the lot number of the filters. In addition, allow at least 500 mL of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

5.3.6.2 FIELD SAMPLING PRESERVATION

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples, and may require normalization of results. Guidance for the preservation of environmental samples can be found in the EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other EPA documents (EPA 1992, 1996).

5.3.6.3 FIELD SAMPLING LOG

A groundwater sampling log (Figure I-C-3-1) shall document the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis

- Field analysis data
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature

6. Records

Document information collected during groundwater sampling on the groundwater sampling log form in indelible ink (Figure I-C-3-1). Send copies of this information to the CTO Manager and to the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

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Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody.*

9. Attachments

None.

Drum Sampling

1. Purpose

This standard operating procedure describes the methods by which United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel will sample drum(s) at hazardous waste and non-hazardous waste sites. Prior to disturbing and handling drums of unknown origin and/or with unknown contents, approval from the Navy will be required.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program. As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that drums of concern are handled and sampled according to this procedure. The CTO Manager is responsible for ensuring that all personnel involved in drum sampling have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that these procedures and the work plan (WP) are followed when drums are sampled.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 METHOD SUMMARY

Prior to sampling, drums should be inventoried, staged, and opened. Inventorying entails recording the visible qualities of each drum and any characteristics pertinent to classification of the contents. Staging involves the organization, and sometimes consolidation, of drums containing similar wastes or that share characteristics. Closed drums may be opened manually or remotely. In the interest of worker safety, it is required to open drums remotely unless the drum contents are known not to present any potential physical or chemical threat to workers. Analytical results from associated field samples may be used to evaluate potential threats. The most widely used method of sampling a drum containing liquids involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and does not require decontamination. Additional information related to drum sampling is available in Section 8, References.

5.2 INTERFERENCE AND POTENTIAL PROBLEMS

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used. Any necessary air monitoring should be conducted when working near over-pressurized drums.

Do not move drums that are over-pressurized to the extent that the head is swollen several inches above the level of the chime (the protruding rings at the top and bottom of the drum). A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum, and the gas vents along the grooves. The venting should be done remotely (e.g., using a backhoe bucket) from behind a wall or barricade. Once the pressure has been relieved, the bung can be removed and the drum sampled. It is necessary that personnel experienced in sampling of over-pressurized or unknown drum contents, or known hazardous waste contents, perform this task. If project team personnel are not experienced in this type of sampling, it is recommended that a subcontractor experienced in this type of sampling implement this portion of the sampling.

5.3 EQUIPMENT/APPARATUS

The following are standard materials and equipment required for sampling:

- An approved site-specific sampling plan and health and safety plan (HSP)
- Personal protection equipment
- Sample containers appropriate for the matrix being sampled
- Uniquely numbered sample identification labels
- One-gallon covered cans half-filled with absorbent packing material, to be used as necessary to hold waste
- Chain-of-custody sheets
- Decontamination equipment (Procedure I-F, *Equipment Decontamination*.)
- Glass thieving tubes, composite liquid waste sampler (COLIWASA), or equivalent
- Drum-opening devices
- Monitoring equipment for the detection of toxic and explosive environments, whenever the contents are not known

5.3.1 Drum-Opening Devices

5.3.1.1 BUNG WRENCH

A common method for opening drums manually is using a universal bung wrench. The fittings on a bung wrench are made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium, non-sparking alloy. The use of a non-sparking wrench does not eliminate the possibility of producing a spark.

5.3.1.2 DRUM DEHEADER

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to partially or completely cut off the lid of a drum by means of scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums. Drums with removable heads or over-pressurized drums should be opened by other means.

5.3.1.3 BACKHOE SPIKE

The most common means of opening drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

5.3.1.4 HYDRAULIC DRUM OPENER

Hydraulic drum openers use hydraulic pressure to pierce the drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line attached to a metal point that pierces the side or head of the drum.

5.3.1.5 PNEUMATIC DEVICES

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system positions and aligns the pneumatic drill over the bung. The bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. The pneumatic bung opener does not permit the slow venting of the container, and therefore, appropriate precautions must be taken. The pneumatic bung opener also requires the container to be upright and relatively level. This device cannot remove bungs that are rusted shut.

5.4 SAMPLING PROCEDURE

5.4.1 Drum Staging

Prior to sampling, stage the drums (if not already staged) for easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum with unknown contents or visibly over-pressurized should explode or catch fire when opened.

During staging, physically separate the drums into the following categories: those containing liquids; those containing solids; lab packs; gas cylinders; and those that are empty. The strategy for sampling and handling drum/containers in each of these categories will be different. Categories are determined by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open top drums. Closed head drums with a bung opening generally contain liquid.
- Visual inspection of the contents of the drum during sampling, followed by restaging, if needed.

For discovered drums that require excavation, eliminate immediate hazards by over packing or transferring the drum's contents to another suitable container, affixing with a numbered tag, and transferring to a staging area. Use color-coded tags, labels, or bands to mark similar waste types. Record a description of each drum, its condition, any unusual markings, and the location where it was buried or stored on a drum data sheet (see Attachment I-D-1-1.) This data sheet becomes the principal record-keeping tool for tracking the drum on site.

Where space allows, physically separate the unknown or suspected hazardous waste-containing or over-pressurized drum opening area from the drum removal and drum staging operations. Move drums from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

5.4.2 Drum Opening

There are three techniques for opening drums at suspected or known hazardous waste sites:

- Manual opening with non-sparking bung wrenches
- Drum deheading
- Remote drum puncturing and bung removal

The choice of drum opening technique and accessories depends on the number of drums to be opened, their waste contents, and their physical condition. Remote drum opening equipment should always be considered to protect worker safety. Under Occupational Safety and Health Administration 1910.120 (OSHA 1998), manual drum opening with bung wrenches or deheaders should be performed only on structurally sound drums whose waste contents are known not to be shock sensitive, reactive, explosive, or flammable.

5.4.2.1 MANUAL DRUM OPENING

Bung Wrench

Do not perform manual drum opening with bung wrenches unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. If opening the drum with bung wrenches is deemed reasonably cost-effective and safe, then certain procedures should be implemented to minimize the hazard:

- Field personnel should be fully outfitted with protective gear.
- Continually monitor atmospheres for toxicity, explosivity, and if applicable, radioactivity.

- Position drums upright with the bung up, or, for drums with bungs on the side, laid on their sides with the bung plugs up.
- The wrenching motion should be a slow, steady pull across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, attach a “cheater bar” to the handle to improve leverage.

5.4.2.2 DRUM DEHEADING

Do not perform drum deheading unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off, if desired. If the top chime of a drum has been damaged or badly dented, it may not be possible to cut the entire top off. Because there is always the possibility that a drum may be under pressure, make the initial cut very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote method prior to using the deheader.

Self-propelled drum openers, which are either electrically or pneumatically driven, are available and can be used for quicker and more efficient deheading.

5.4.2.3 REMOTE OPENING

Remotely operated drum opening tools are the safest available means of opening a drum. Remote drum opening is slow, but provides a high degree of safety compared to manual methods of opening.

Backhoe Spike

“Stage” or place drums in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, punching a hole in the drumhead or lid with the spike can quickly open the drums.

Decontaminate the spike after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is used, mounting a large shatter-resistant shield in front of the operator’s cage can protect the operator of the backhoe. When combined with the normal personal protection gear, this practice should protect the operator. Providing the operator with an on-board air line system affords additional respiratory protection.

Hydraulic Devices

Hydraulic devices consist of a piercing device with a metal point that is attached to the end of a hydraulic line and is pushed into the drum by hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head of the drum. Some of the metal piercing devices are hollow or tube-like so that they can be left in place, if desired, to serve as a permanent tap or sampling port. The piercing device is designed to establish a tight seal after penetrating the container.

Pneumatic Devices

Pneumatically operated devices using compressed air have been designed to remove drum bungs remotely.

5.4.3 Drum Sampling

Immediately after the drum has been opened, sample the headspace gases within the drum using an explosimeter, organic vapor analyzer, and/or a photoionization detector, and record the data on the Drum Data Sheet (see Attachment I-D-1-1) as necessary. The CTO WP shall reference procedures listed in the site HSP.

In most cases, it is impossible to observe the contents of these sealed or partially sealed drums. Because some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel. In addition, a sample of solid material collected from a drum should include the entire depth to be most representative of the drum contents.

When sampling a previously sealed drum, check for the presence of bottom sludge. This is easily accomplished by measuring the depth to apparent bottom, and then comparing it to the known interior depth.

5.4.3.1 GLASS THIEF SAMPLER

The most widely used implement for sampling liquids in a drum is a glass tube (glass thief, 6 millimeters inner diameter × 30.47 centimeters [cm] [48 inches] length). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate.

Specific Sampling Procedure Using a Glass Thief

1. Remove the cover from the sample container.
2. Slowly insert the glass tubing almost to the bottom of the drum or until a solid layer is encountered. About 1 foot of tubing should extend above the drum.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with the stopper.
5. Carefully remove the capped tube from the drum, and insert the uncapped end into the sample container. Do not spill liquid on the outside of the sample container.
6. Release the stopper, and allow the glass thief to drain completely into the sample container. Fill the container to about 2/3 of capacity.
7. Remove the tube from the sample container, carefully break it into pieces, and place the pieces in the drum.
8. Cap the sample container tightly, and place the pre-labeled sample container in a carrier.
9. Replace the bung or place plastic over the drum.
10. Transport the sample to the decontamination zone to be prepared for transport to the analytical laboratory.

In many instances, a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sampling tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

In some instances, disposal of the tube by breaking it into the drum might interfere with eventual plans for the removal of its contents. Clear this technique with NAVFAC Pacific personnel or evaluate other disposal techniques.

5.4.3.2 COLIWASA SAMPLER

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. It collects a sample from the full depth of a drum and maintains it in the transfer tube until delivery to the sample bottle. One configuration consists of a 152 cm by 4 cm-inner diameter section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The major drawbacks associated with using a COLIWASA include decontamination and cost. The sampler is difficult (if not impossible) to decontaminate in the field, and its high cost relative to alternative procedures (glass tubes) make it an impractical throwaway item. However, disposable, high-density, inert polyethylene COLIWASAs are available at a nominal cost. Although the applications of a disposable COLIWASA are limited, it is especially effective in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Open the sampler by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler’s locking block.
2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
4. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
6. Cap the sample container with a Teflon-lined cap, attach a label and seal, and record it on the sample data sheet.
7. Unscrew the T-handle of the sampler, and disengage the locking block.
8. Clean the sampler.

5.5 DRUM CLOSING

Upon completion of sampling activities, close the drums, and then store them in a secure area as described in Procedure I-A-6, *Investigation-Derived Waste Management*. If the bung opening and the bung are still intact, then close the drum by replacing the bung. In addition, open top drums that are still in good condition can be closed by replacing the top and securing the drum ring with the attached bolt.

If a drum cannot be closed in the manner discussed above, then secure it by placing it in an approved 85-gallon overpack drum (type UN 1A2/Y43/S). Fill the void spaces between the outer portion of the inner drum and the inside of the overpack drum with vermiculite to secure the drum contents to the extent possible.

5.6 EQUIPMENT DECONTAMINATION

Decontamination of sampling equipment should follow Procedure I-F, *Equipment Decontamination*.

5.7 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

1. Do not add preservatives to the sample unless specifically required by the analytical method or WP.
2. Place the labeled sample container in two re-sealable plastic bags.
3. If the contents of the investigation-derived waste drum are unknown, or known to contain hazardous waste, place each bagged sample container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
4. Mark the sample identification number on the outside of the can.
5. Place the samples in a cooler, and fill the remaining space with absorbent packing material.
6. Fill out the chain-of-custody record for each cooler, place it in a re-sealable plastic bag, and affix it to the inside lid of the cooler.
7. Secure the lid of the cooler, and affix the custody seal.
9. Arrange for the appropriate transport mode consistent with the type of waste involved (hazardous or non-hazardous).

6. Records

Keep records of all sampling activities in the field notebook and on the Drum Data Sheets. Document sample custody on the chain-of-custody form. The CTO Manager shall review these documents at the completion of field activities, and, at least on a monthly basis for long-term projects.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Occupational Safety and Health Administration (OSHA). 1998. *Occupational Safety and Health Standards* (29 CFR 1910); with special attention to Section 1910.120, *Hazardous Waste Operations and Emergency Response (HAZWOPER)*. Washington, DC: United States Department of Labor.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

9. Attachments

Attachment I-D-1-1: Drum Data Sheet

Attachment I-D-1-1
Drum Data Sheet

DRUM DATA SHEET

CTO/DO #: ____________ Date Sampled: ____________

Drum I.D.#: ____________ Time: ____________

Estimated Liquid Quantity: ____________

Original Drum Location: ____________

Staging Location: ____________

Sampler's Name: ____________

Drum Condition: ____________

Physical Appearance of the Drum/Bulk Contents: ____________

Headspace Gas Concentration: ____________

Odor: ____________ Color: ____________

pH: ____________ % Liquid: ____________

Laboratory Date of Analysis: ____________

Analytical Data: ____________

Compatibility: ____________

Hazard: ____________

Waste I.D.: ____________

Treatment Disposal Recommendations: ____________

Soil and Rock Classification

1. Purpose

This section sets forth standard operating procedures for soil and rock classification for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil and rock classification procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual is defined as a person with a degree in geology, hydrogeology, soil science, or geotechnical/civil engineering with at least 1 year of experience classifying soil. Supervision is defined as onsite and continuous monitoring of the individual conducting soil classification. The CTO Manager is responsible for ensuring that all personnel involved in soil and rock classification have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The CTO Manager is responsible for reviewing copies of the field boring log forms on a monthly basis at a minimum. However, it is recommended that initially boring logs are reviewed daily to ensure accuracy.

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 SOIL CLASSIFICATION

The basic purpose of the classification of soil is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system for the NAVFAC Pacific ER Program. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serve as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but also a complete word description.

Describing soil on a common basis is essential so that soil described by different site qualified personnel is comparable. Site individuals describing soil as part of site activities *must* use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions, such as density/consistency, compaction, amount of induration/cementation or weathering, retention of the parent rock fabric, and structure
- USCS classification symbol

The USCS serves as “shorthand” for classifying soil into 15 basic groups:

GW[1]	Well graded (poorly sorted) gravel (>50 percent gravel, <5percent fines)
GP[1]	Poorly graded (well sorted) gravel (>50percent gravel, <5percent fines)
GM[1]	Silty gravel (>50 percent gravel, >15 percent silt)
GC[1]	Clayey gravel (>50 percent gravel, >15 percent clay)
SW[1]	Well graded (poorly sorted) sand (>50 percent sand, <5 percent fines)
SP[1]	Poorly graded (well sorted) sand (>50 percent sand, <5 percent fines)
SM[1]	Silty sand (>50 percent sand, >15 percent silt)
SC[1]	Clayey sand (>50 percent sand, >15 percent clay)

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[1] If percentage of fine is 5 percent to 15 percent, a dual identification shall be given (e.g., a soil with more than 50 percent poorly sorted gravel and 10 percent clay is designated GW-GC.

ML[2]	Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness, and plasticity)
CL[2]	Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)
MH[2]	Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)
CH[2]	Inorganic, high plasticity (fat) clay (no dilatancy, high toughness, and plasticity)
OL	Organic low plasticity silt or organic silty clay
OH	Organic high plasticity clay or silt
PT	Peat and other highly organic soil

Figure I-E-1 defines the terminology of the USCS. Flow charts presented in Figure I-E-2 and Figure I-E-3 indicate the process for describing soil. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification (e.g., SC/CL) if the soil has been identified as having properties that do not distinctly place the soil into one group.

5.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. Being proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below:

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5-inch diameter sample liner).
2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.
3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch).
4. Considering the rest of the sample, estimate, and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).
5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).
6. Estimate percentages to the nearest 5 percent. If one of the components is present in a quantity considered less than 5 percent, indicate its presence by the term “trace.”
7. The percentages of gravel, sand, and fines must add up to 100 percent. “Trace” is not included in the 100 percent total.

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[2] If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words “with sand” or “with gravel” (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30 percent or more sand or gravel, or both, the words “sandy” or “gravely” (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use “sandy.”

5.1.2 Soil Dilatancy, Toughness, and Plasticity

5.1.2.1 DILATANCY

To evaluate dilatancy, follow these procedures:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 millimeters [mm]) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
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 I-E-1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table I-E-1: Criteria for Describing Dilatancy

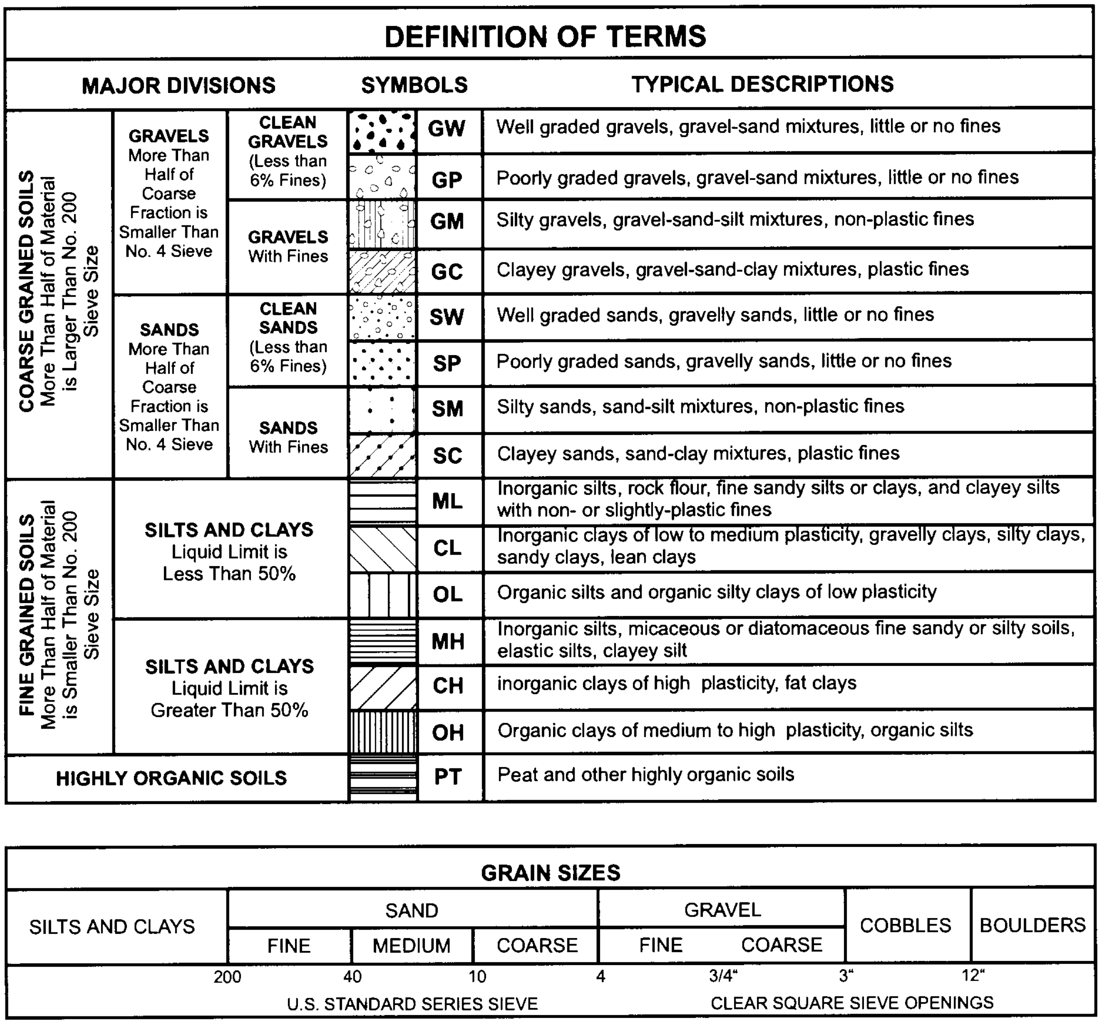
Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

5.1.2.2 TOUGHNESS

Following the completion of the dilatancy test, shape the test specimen into an elongated pat and roll it by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, spread it into a thin layer and allow it to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch 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, lump the pieces together and knead it until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table I-E-2.

Table I-E-2: 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 near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread near the plastic limit. The thread and the lump have very high stiffness.



DEFINITION OF TERMS

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	**GRAVELS** More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN GRAVELS** (Less than 6% Fines)	▨	**GW**	Well graded gravels, gravel-sand mixtures, little or no fines
			▨	**GP**	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	▨	**GM**	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			▨	**GC**	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN SANDS** (Less than 6% Fines)	▨	**SW**	Well graded sands, gravelly sands, little or no fines
			▨	**SP**	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	▨	**SM**	Silty sands, sand-silt mixtures, non-plastic fines
			▨	**SC**	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	**SILTS AND CLAYS** Liquid Limit is Less Than 50%		▨	**ML**	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			▨	**CL**	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			▨	**OL**	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		▨	**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			▨	**CH**	inorganic clays of high plasticity, fat clays
			▨	**OH**	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			▨	**PT**	Peat and other highly organic soils

GRAIN SIZES

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		
200	40	10	4	3/4"	3"	12"	
	U.S. STANDARD SERIES SIEVE			CLEAR SQUARE SIEVE OPENINGS			

Figure I-E-1: Unclassified Soil Classification System (USCS)

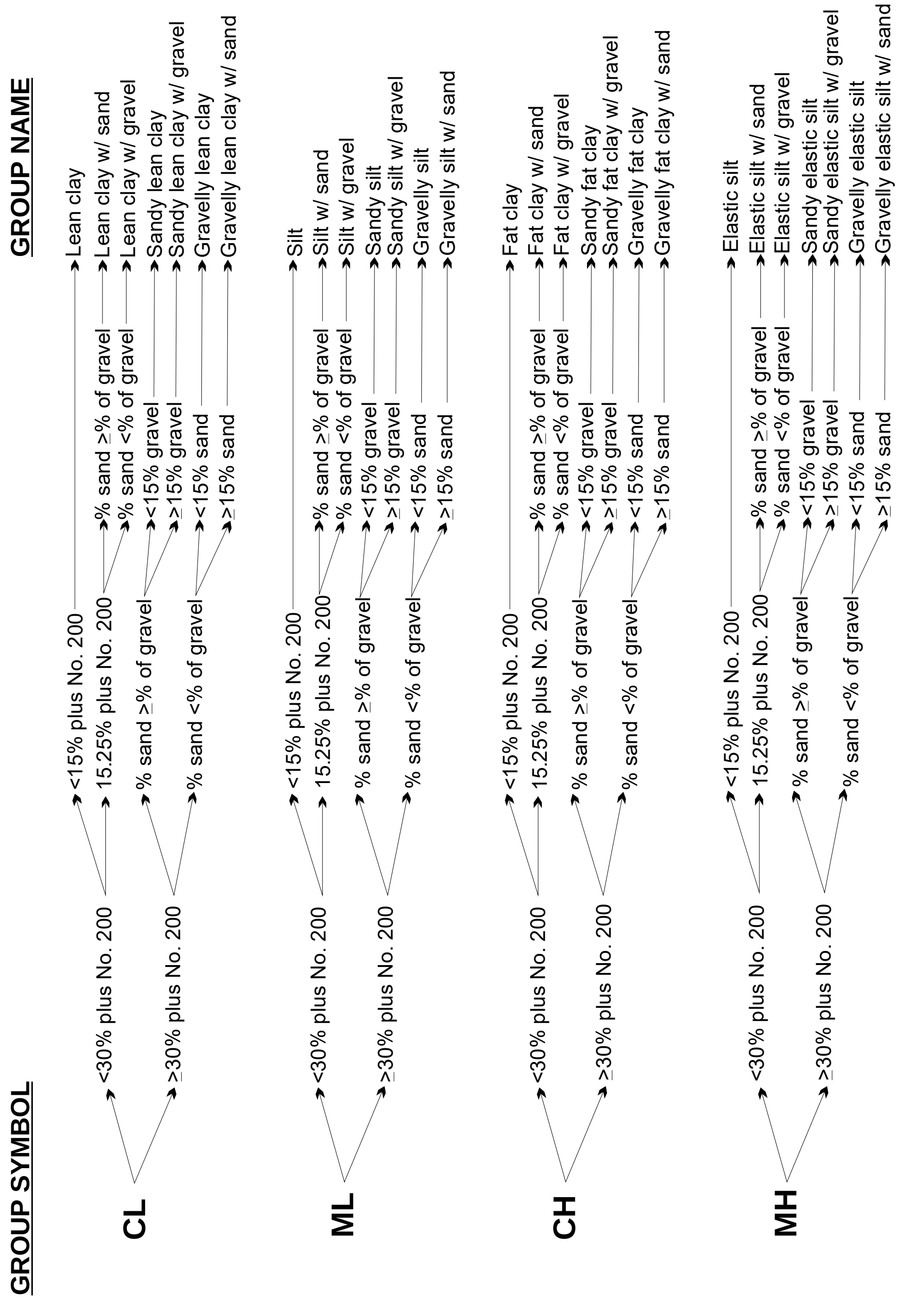


Figure I-E-2: Flow Chart for Fine Grain Soil Classification

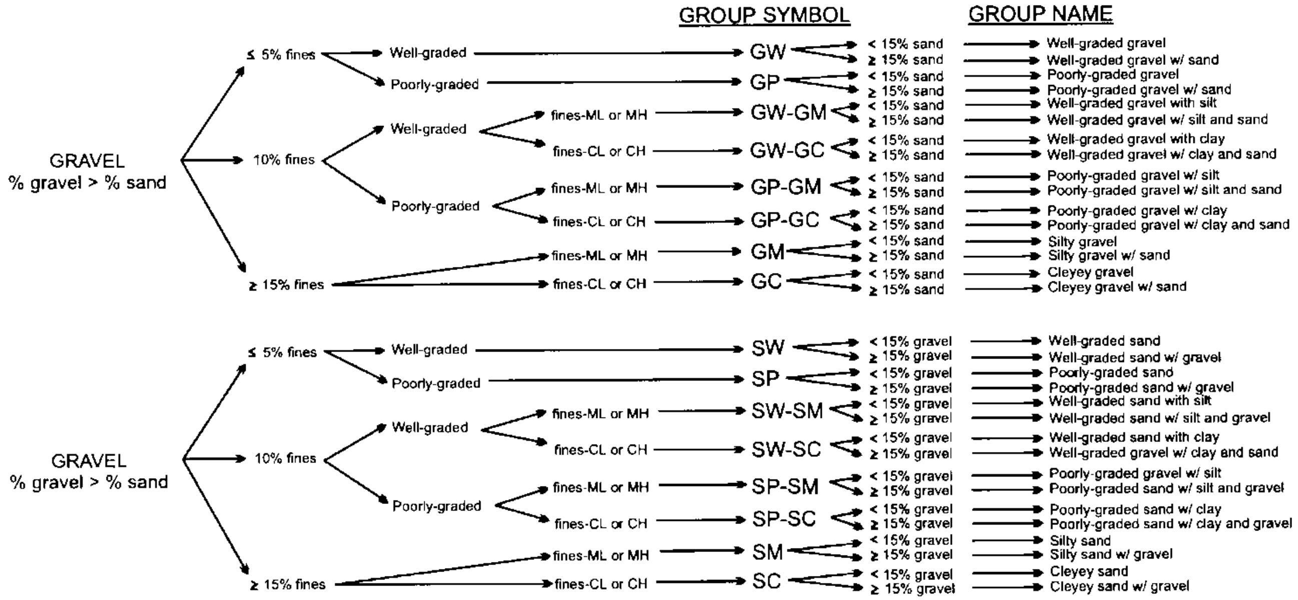


Figure I-E-3: Flow Chart for Soil with Gravel

5.1.2.3 PLASTICITY

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials is defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content, but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, add water prior to performing classification. If a soil sample is too sticky, spread the sample thin and allow it to lose some soil moisture.

Table I-E-3 presents the criteria for describing plasticity in the field using the rolled thread method.

Table I-E-3: Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low Plasticity	The thread can barely be rolled.
Medium Plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High Plasticity	It takes considerable time rolling the thread to reach the plastic limit.

5.1.3 Angularity

The following criteria describe the angularity of the coarse sand and gravel particles:

- *Rounded* particles have smoothly-curved sides and no edges.
- *Subrounded* particles have nearly plane sides, but have well-rounded corners and edges.
- *Subangular* particles are similar to angular, but have somewhat rounded or smooth edgesand.
- *Angular* particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

5.1.4 Color, Moisture, and Odor

The natural moisture content of soil is very important. Table I-E-4 shows the terms for describing the moisture condition and the criteria for each.

Table I-E-4: Soil Moisture Content Qualifiers

Qualifier	Criteria
Dry	Absence of moisture, dry to the touch
Moist	Damp but no visible water
Wet	Visible water, usually soil is below water table

Color is described by hue and chroma using the Munsell Soil Color Chart (Munsell 2000). For uniformity, all site geologists shall use this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists The Munsell Color Chart is a small booklet of numbered color chips with names like “5YR 5/6, yellowish-red.” Note mottling or banding of colors. It is particularly important to note and describe staining because it may indicate contamination.

In general, wear a respirator if strong organic odors are present. If odors are noted, describe them if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer may be used to detect the presence of volatile organic contaminants.

5.1.5 In-Place Conditions

Describe the conditions of undisturbed soil samples in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

5.1.5.1 DENSITY/CONSISTENCY

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term “density” is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term “consistency” is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 pounds (63.5 kilograms) dropped over a distance of 30 inches (0.76 meters). Record the number of blows required to penetrate each 6 inches of soil in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded, but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the “standard penetration resistance,” or the “N-value.” The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch inner diameter Modified California Sampler equipped with brass or stainless steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

Drive the sampler and record blow counts for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed "refusal" and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, record the number of blows per partial increment on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Table I-E-5 and Table I-E-6 present representative descriptions of soil density/consistency vs. N-values.

Table I-E-5: Measuring Soil Density with a California Sample – Relative Density (Sands, Gravels)

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.43 factor
Very Loose	0–4	0–6
Loose	4–10	6–14
Medium Dense	10–30	14–43
Dense	30–50	43–71
Very Dense	>50	>71

Table I-E-6: Measuring Soil Density with a California Sampler – Fine Grained Cohesive Soil

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.13 factor
Very Soft	0–2	0–2
Soft	2–4	2–4
Medium Stiff	4–8	4–9
Stiff	8–16	9–18
Very Stiff	16–32	18–36
Hard	>32	>36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot. The values are as follows (Table I-E-7):

Table I-E-7: Measuring Soil Consistency with a Hand-Held Penetrometer

Description	Pocket Penetrometer Reading (psf)
Very Soft	0–250
Soft	250–500
Medium Stiff	500–1,000
Stiff	1,000–2,000
Very Stiff	2,000–4,000
Hard	>4,000

Consistency can also be estimated using thumb pressure using Table I-E-8.

Table I-E-8: Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

5.1.5.2 CEMENTATION

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

1. Quartz – siliceous
2. Chert – chert-cemented or chalcedonic
3. Opal – opaline
4. Carbonate – calcitic, dolomitic, sideritic (if in doubt, calcareous should be used)
5. Iron oxides – hematitic, limonitic (if in doubt, ferruginous should be used)
6. Clay minerals – if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as “kaolin-cemented,” “chlorite-cemented,” etc.
7. Miscellaneous minerals – pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

1. Weak – friable; crumbles or breaks with handling or slight finger pressure
2. Moderate – friable; crumbles or breaks with considerable finger pressure
3. Strong – not friable; will not crumble or break with finger pressure

5.1.5.3 STRUCTURE

This variable is used to qualitatively describe physical characteristics of soil that are important to incorporate into hydrogeological and/or geotechnical descriptions of soil at a site. Appropriate soil structure descriptors are as follows:

- *Granular:* Spherically shaped aggregates with faces that do not accommodate adjoining faces
- *Stratified:* Alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
- *Laminated:* Alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness
- Blocky: Cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown
- *Lensed:* Inclusion of a small pocket of different soil, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soil are present, the soil being described can be termed homogeneous if the description of the lenses is included
- *Prismatic or Columnar:* Particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top
- *Platy:* Particles are arranged about a horizontal plane

5.1.5.4 OTHER FEATURES

- *Mottled:* Soil that appears to consist of material of two or more colors in blotchy distribution
- *Fissured:* Breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)
- *Slickensided:* Fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

5.1.6 Development of Soil Description

Develop standard soil descriptions according to the following examples. There are three principal categories under which all soil can be classified. They are described below.

5.1.6.1 COARSE-GRAINED SOIL

Coarse-grained soil is divided into sands and gravels. A soil is classified as a sand if over 50 percent of the coarse fraction is "sand-sized." It is classified as a gravel if over 50 percent of the coarse fraction is composed of "gravel-sized" particles.

The written description of a coarse-grained soil shall contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); grain size of coarse fraction; Munsell color and color number; moisture content; relative density; sorting; angularity; other features, such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts) in parentheses.

Example: POORLY SORTED SAND WITH SILT, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20 percent coarse-grained sand-sized shell fragments, and 80 percent medium-grained quartz sand, and 5 percent to 15 percent ML).

5.1.6.2 FINE-GRAINED SOIL

Fine-grained soil is further subdivided into clays and silts according to its plasticity. Clays are rather plastic, while silts have little or no plasticity.

The written description of a fine-grained soil should contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); Munsell color; moisture content; consistency; plasticity; other features, such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: SANDY LEAN CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70 percent fines, 30 percent sand, with minor amounts of disarticulated bivalves [about 5 percent]).

5.1.6.3 ORGANIC SOIL

For highly organic soil, describe the types of organic materials present as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil usually has a dark brown to black color and may have an organic odor. Often, organic soils will change color, (e.g., from black to brown) when exposed to 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.

Example: ORGANIC CLAY, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100 percent fines), weak reaction to HCl.

5.2 ROCK CLASSIFICATION

The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed for the NAVFAC Pacific ER Program because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site work plan. Both the CTO Manager and the QA Manager or

Technical Director must approve any modifications to this classification system, or the use of another classification system.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens as a part of investigative activities must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

A rock classification template has been designated as shown in Figure I-E-4 to provide a more consistent rock classification between geologists. The template includes the classification of rocks by origin and mineralogical composition. When classifying rocks, all site geologists shall use this template.

The site geologist shall describe the rock specimen and record the description in a borehole log or logbook. The items essential for classification include:

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphanitic, glassy)
- Structure (i.e., foliated, fractured, lenticular)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage)
- Classification symbol (i.e., MF)

Example: Metamorphic foliated schist: Olive gray, 5Y, 3/2, Garnet 25 percent, Quartz 45 percent, Chlorite 15 percent, Tourmaline 15 percent, Fine-grained with Pegmatite garnet, highly foliated, slightly wavy, MF.

6. Records

Document soil classification information collected during soil sampling onto the field boring logs, field trench logs, and into the field notebook. Procedure I-B-1, *Soil Sampling* presents copies of the field boring log form. Copies of this information shall be placed in the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Folk, Robert L. 1980. *Petrology of Sedimentary Rocks*. Austin, TX: Hemphill Publishing Company.

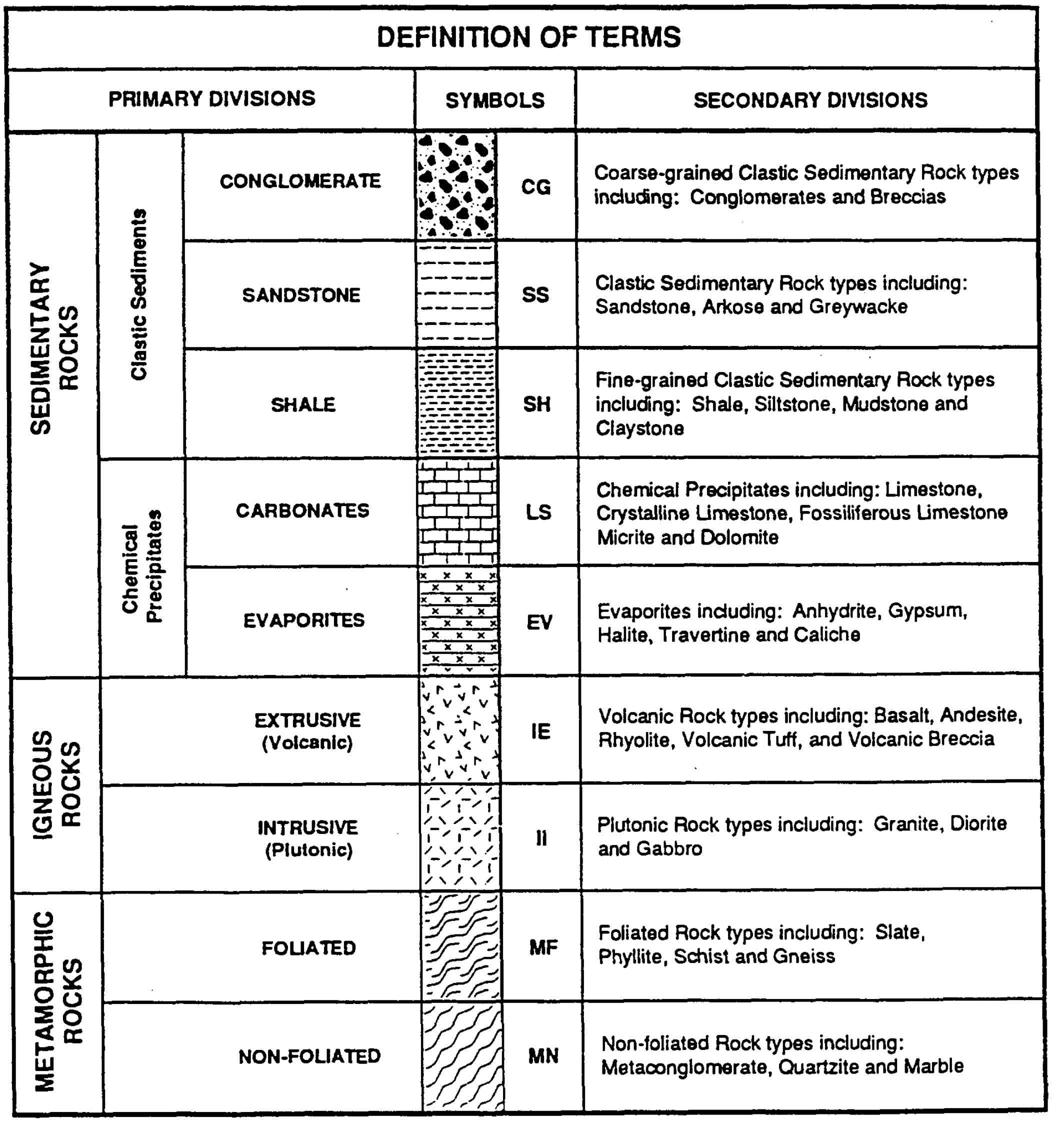
Munsell Color Company (Munsell). 2009. *Munsell Soil Color Chart*, (Revised). Baltimore.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-1, *Soil Sampling*.

9. Attachments

None.



DEFINITION OF TERMS

PRIMARY DIVISIONS			SYMBOLS	SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE	CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
		SANDSTONE	SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
		SHALE	SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
	Chemical Precipitates	CARBONATES	LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
		EVAPORITES	EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS		EXTRUSIVE (Volcanic)	IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
		INTRUSIVE (Plutonic)	II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS		FOLIATED	MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
		NON-FOLIATED	MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

Figure I-E-4: Rock Classification System

Equipment Decontamination

1. Purpose

This standard operating procedure describes methods of equipment decontamination for use during site activities by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for identifying instances of non-compliance with this procedure and ensuring that decontamination activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in equipment decontamination have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Decontamination of equipment used in sampling of various media, groundwater monitoring, and well drilling and development is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- The location where the decontamination procedures will be conducted
- The types of equipment requiring decontamination
- The frequency of equipment decontamination
- The cleaning technique and types of cleaning solutions appropriate for the contaminants of concern
- The method for containing the residual contaminants and wash water from the decontamination process
- The use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsection describes standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 DECONTAMINATION AREA

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

It is the responsibility of the site safety and health officer (SSHO) to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally, the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. For equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing laboratory-grade isopropyl alcohol (or alternative cleaning solvent as described in the CTO work plan [WP]) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

5.2 TYPES OF EQUIPMENT

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. However, equipment that is shipped pre-packaged from the vendor should not have to be decontaminated prior to first use. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

5.3 FREQUENCY OF EQUIPMENT DECONTAMINATION

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 CLEANING SOLUTIONS AND TECHNIQUES

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment, and rinse it with potable tap water to remove particulates and contaminants.

Where appropriate, disposable materials are recommended. A rinse decontamination procedure is acceptable for equipment, such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (alconox, liquinox, or other suitable detergent) and potable water solution; (2) rinse in a bath with potable water; (3) spray with laboratory-grade isopropyl alcohol; (4) rinse in a bath with deionized or distilled water; and (5) spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and potable water; (2) potable water rinse; (3) potable water rinse; and (4) deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent. However, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated concentrations of metals. Decontamination solvents to be used during field activities will be specified in CTO WP and site-specific health and safety plan.

Rinse equipment used for measuring field parameters, such as pH, temperature, specific conductivity, and turbidity with deionized or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 CONTAINMENT OF RESIDUAL CONTAMINANTS AND CLEANING SOLUTIONS

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drilling rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results. Label containers in accordance with Procedure I-A-6, *Investigation-Derived Waste Management*.

5.6 EFFECTIVENESS OF DECONTAMINATION PROCEDURES

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. Procedure III-B, *Field QC Samples (Water, Soil)* provides further descriptions of these samples and their required frequency of collection. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

6. Records

Describe the decontamination process in the field logbook.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure III-B, *Field QC Samples (Water, Soil).*

9. Attachments

None.

Procedure I-I
Land Surveying

Land Surveying

1. Purpose

This standard operating procedure sets forth protocols for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites for use by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the *Uniform Federal Policy-Quality Assurance Project Plan* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 BOUNDARY SURVEY

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

3.2 GLOBAL POSITIONING SYSTEM (GPS)

A GPS is a system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

3.3 WAYPOINT

A waypoint is a reference point or set of coordinates that precisely identify a location.

4. Responsibilities

The prime contractor CTO Manager is responsible for determining the appropriate land surveying protocols for the project and ensuring this procedure is properly implemented. The CTO Manager is responsible for ensuring that all personnel involved in land surveying shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for ensuring that the appropriate protocols are conducted according to this procedure and the project-specific sampling plan. In virtually all cases, subcontractors will conduct these procedures. The FM is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 THEODOLITE/ELECTRONIC DISTANCE MEASUREMENT (EDM)

Follow the procedures listed below during theodolite/EDM land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer’s representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- Reference surveyed points to mean sea level (lower low water level).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the CTO Manager.
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.

- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.2 GLOBAL POSITIONING SYSTEM (GPS) TO CONDUCT LAND SURVEY

Follow the procedures listed below during GPS land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer's representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet. Accuracy requirements shall be specified in the project work plan (WP).
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project WP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.3 GLOBAL POSITIONING SYSTEM (GPS) TO POSITION SAMPLE LOCATIONS OR LOCATE SITE FEATURES

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically when a level of precision greater than (±) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (±) 3 to 5 meters is sufficient to meet project requirements (i.e., when laying sampling grids, identifying significant site features, or locating features identified in geographic information system [GIS] figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available GPS unit with wide angle averaging system (WAAS), topographic map display, and waypoint storage capabilities should be used.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used. For Guam this is typically WGS84, Zone 55N. For Hawaii this will either be NAD83 Zone 3 and 4 or WGS84 Zone 5N.
- If a permanent reference point near the site is available, it is recommended that the reference point is surveyed each day the GPS unit is used.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e., building corner, roadway intersection, or USGS benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (±) 5 meters as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units “Go To” function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labeled.
- It is recommended that GPS coordinates be uploaded to a storage device such as a personal computer at the end of each day.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a WAAS system at the site, this should also be noted.

6. Records

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey
- General weather conditions
- The name of the surveying firm
- The names and job titles of personnel performing the survey work
- Equipment used, including serial numbers
- Field book designations, including page numbers

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

9. Attachments

None.

Data Validation

1. Purpose

This procedure describes the presentation format and information provided in the data validation reports under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific. The objective of data validation is to provide data of known quality to the end user. This procedure also establishes the method by which a Contract Task Order (CTO) Manager selects and confirms the content of data validation reports and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013).

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012) and 2B (2005b) as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA manager) shall also concur with any deviations.

3. Definitions

Acronyms and abbreviations used in all data validation procedures and reports are defined in Attachment II-A-1. Commonly used terms are defined in Attachment II-A-2.

4. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for all data validation reports.

5. Procedure

5.1 INTRODUCTION

This procedure addresses the validation of data obtained under the NAVFAC Pacific ER Program using primarily U.S. Environmental Protection Agency (EPA) Solid Waste (SW)-846 methods (EPA 2007). Based on the data validation requirements identified in the CTO project planning documents, the analytical data may undergo “Level B,” “Level C,” or “Level D” data validation or some combination of these validation levels. This procedure establishes the required format and content of the various validation reports.

5.1.1 Confirmation of Data Validation Reports

Prior to shipment of all completed data validation reports to the CTO Manager, a single draft report for one sample delivery group (SDG) should be submitted. The CTO Manager shall review the draft report to confirm that the report contains the requested information, and respond to the Data Validation Project Manager in a timely manner. Once the requested contents are confirmed, the complete data validation packages should be delivered to the CTO Manager.

5.2 CONTENT AND FORMAT OF THE DATA VALIDATION REPORT

The data validation report will consist of the following four major components:

1. Cover letter
2. Data validation reference package comprising:
   a. Cover page
   b. Acronyms and abbreviations list
   c. Data qualifier reference table
   d. Qualification code reference table
3. Individual data validation reports by SDG:
   e. Cover page
   f. Introduction
   g. Data validation findings
   h. Appendix of laboratory reports with applied data qualifiers

A discussion of the contents and format of these components is provided in the following sections.

5.2.1 Cover Letter

The cover letter will contain the generation date of the cover letter, the address of the CTO office, the CTO number, and the CTO Manager's name or designee. The cover letter will list the specific reports being sent under that cover letter. A senior data reviewer must review the report and sign the cover letter to denote approval. Attachment II-A-3 is an example of the cover letter.

5.2.2 Data Validation Reference Package

One data validation reference package shall be provided per CTO and shall contain the reference information needed for interpretation of the individual data validation reports. The following sections shall be included:

5.2.2.1 COVER PAGE

The cover page shall indicate the CTO title and number to which the reference package applies.

5.2.2.2 ACRONYMS AND ABBREVIATIONS LIST

This list shall present all acronyms and abbreviations used in the individual data validation reports. Attachment II-A-1 is an example of the acronyms and abbreviations list.

5.2.2.3 DATA QUALIFIER REFERENCE TABLE

Data qualifiers are applied in cases where the data do not meet the required quality control (QC) criteria or where special consideration by the data user is required.

The data qualifier reference table lists the data qualifiers used in the validation of the analytical data. Attachment II-A-4 is an example of this table.

5.2.2.4 QUALIFICATION CODE REFERENCE TABLE

Qualification codes explain why data qualifiers have been applied and identify possible limitations of data use. Attachment II-A-5 provides the qualification codes used by the NAVFAC Pacific ER Program. Qualification codes are to be provided by data validation personnel on the annotated laboratory reports discussed in Section 5.2.3.4.

5.2.3 Individual Data Validation Reports by SDG

For all analyses, each SDG shall have a unique data validation report. The procedures used to generate the reports are discussed in the following sub-sections.

5.2.3.1 COVER PAGE

The cover page shall indicate the CTO title and number, analysis type, and the SDG(s), which the report addresses.

5.2.3.2 INTRODUCTION

This section will contain a brief description of the CTO information that is pertinent to data validation. This information includes the CTO title and number, CTO Manager, the sample matrices and analyses performed on the samples, the data validation level for the project, and a brief discussion of the methodologies used for data validation. This section will also contain a Sample Identification Table which lists the identification of each sample identification number cross referenced with its associated internal laboratory identification number and COC sample number. Each sample will be listed under every analytical method for which data was validated. Attachment II-A-6 is an example of the sample identification table.

5.2.3.3 DATA VALIDATION FINDINGS

This section shall present the data validation findings of the data reviewer for the CTO data package. The findings shall be determined on the basis of validation criteria established for each analytical method[1] in the DoD QSM (DoD 2013) or the CTO planning document and Procedure II-B through Procedure II-X. For all data validation levels, the data validation findings are divided into the following analytical categories:

- II-B GC/MS Volatile Organics by SW-846 Method 8260

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[1] Other methods may be included with approval of the CTO and Data Validation Managers.

- II-C GC/MS Semivolatile Organics by SW-846 8270 (full scan and SIM)
- II-D HRGC/HRMS Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by SW-846 8290
- II-E Organochlorine Pesticides by SW-846 8081
- II-F Polychlorinated Biphenyls as Aroclors by SW-846 8082
- II-G Polychlorinated Biphenyls as Congeners by SW-846 8082
- II-H Total Petroleum Hydrocarbons by SW-846 8015
- II-I Chlorinated Herbicides by SW-846 8151
- II-J Organophosphorus Pesticides by SW-846 8141
- II-K Halogenated and Aromatic Volatiles by SW-846 8021
- II-L Phenols by SW-846 8041
- II-M Ethylene Dibromide/Dibromochloropropane by SW-846 8011
- II-N Polynuclear Aromatic Hydrocarbons by SW-846 8310
- II-O Explosives by SW-846 8330
- II-P Carbamate and Urea Pesticides by EPA Method 632
- II-Q Metals by EPA Method SW-846 6000/7000
- II-R Wet Chemistry Analyses
- II-S Data Quality Assessment Report
- II-T HRGC/HRMS Polychlorinated Biphenyls as Congeners by EPA Method 1668
- II-U Carbamate and Urea Pesticides by SW-846 8321
- II-V Perchlorate by SW-846 6850
- II-W GC/FID/ECD Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Method TO-3 and ASTM D1946
- II-X GC/MS Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Method TO-14, TO-15, and TO-17

GC/MS	gas chromatography/mass spectrometry
ECD	electron capture detector
FID	flame ionization detector
HRGC/HRMS	high resolution gas chromatograph/high resolution mass spectrometer
SIM	selective ion monitoring

Level C and Level D Data Validation

Data obtained using any analytical methods in the above categories will be validated in terms of meeting criteria for specific QA/QC factors such as holding times, instrument calibration, and blank analyses. A separate discussion of each QA/QC factor under each analytical method will be presented in the CTO data validation report. The QA/QC factors used to validate data for Level C and Level D validation are presented below for each analytical category.

Volatile Organics by Gas Chromatography/Mass Spectrometry (GC/MS)

1. Sample management (sample preservation, handling, and transport, chain-of-custody, and holding times)
2. GC/MS instrument performance check
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and laboratory control samples (LCSs)
6. Surrogate recovery
7. Matrix spike/matrix spike duplicate (MS/MSD)
8. Field QC samples (trip blanks, equipment blanks, field blanks, field duplicates, and field triplicates)
9. Internal standards performance
10. Target compound identification (Level D only*)
11. Compound quantitation and reporting limits (RLs) (Level D only*)
12. Tentatively identified compounds (Level D only*)
13. System performance (Level D only*)

Semivolatile Organics by Full Scan and SIM GC/MS

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. GC/MS instrument performance check (full scan)
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. Surrogate recovery
7. MS/MSD
8. Field QC samples (equipment blanks, field blanks, and field duplicates)
9. Internal standards performance
10. Target Compound identification (Level D only*)
11. Compound quantitation and RLs (Level D only*)
12. Tentatively identified compounds (Level D only*)

13. System performance (Level D only*)

Dioxins/Dibenzofurans by HRGC/HRMS

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. HRGC/HRMS instrument performance check
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. MS/MSD
7. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
8. Internal standards performance
9. Target compound identification (Level D only*)
10. Compound quantitation and RLs (Level D only*)
11. System performance (Level D only*)

Organochlorine Pesticides by GC

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Pesticides instrument performance (retention time evaluation, 4,4'-DDT/Endrin breakdown evaluation)
3. Calibration (analytical sequence, initial calibration, initial calibration verification, continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. Surrogate recovery
7. MS/MSD
8. Sample cleanup performance
9. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
10. Target compound identification (Level D only*)
11. Compound quantitation and RLs (Level D only*)

Organic Analyses by GC (QA/QC factors may vary depending on analysis type)

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)

2. Instrument performance
3. Calibration (initial calibration, initial calibration verification and continuing calibration)
4. Method blanks
5. Blank spikes and LCS
6. Surrogate recovery
7. MS/MSD
8. Field QC samples (trip blanks [volatile organic compounds], equipment blanks, field blanks, field duplicates, and field triplicates)
9. Target compound identification (Level D only*)
10. Compound quantitation and RLs (Level D only*)

Organic Analyses by High-Performance Liquid Chromatography (QA/QC factors may vary depending on analysis type)

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Instrument performance
3. Calibration (initial calibration, initial calibration verification and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. Surrogate recovery
7. MS/MSD
8. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
9. Target compound identification (Level D only*)
10. Compound quantitation and reporting limits (RLs) (Level D only*)

Organic Analyses by Liquid Chromatography–Mass Spectrometry (QA/QC factors may vary depending on analysis type)

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Instrument performance
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. MS/MSD
7. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)

8. Internal standards performance
9. Target compound identification (Level D only*)
10. Compound quantitation and RLs (Level D only*)

Metals

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Calibration (initial and continuing)
3. Blanks (Calibration blanks and Method [preparation] blanks)
4. Inductively coupled (argon) plasma (spectroscopy) (ICP) interference check sample
5. Blank spikes and LCSs
6. MS/MSD and Matrix duplicates
7. Furnace atomic absorption QC
8. Internal standards performance (MS methods only)
9. ICP serial dilution
10. Sample result verification (Level D only*)
11. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)

Inorganic Analyses by Wet Chemical Methods, (QA/QC factors may vary depending on analysis type)

1. Sample management (sample preservation, handling, and transport; chain-of-custody; and holding times)
2. Calibration (initial and continuing)
3. Method blanks
4. Blank spikes and LCSs
5. MS/MSD and Matrix duplicates
6. Sample result verification (Level D only*)
7. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)

* Sections applicable to Level D validation only will also appear in Level C validation reports with the notation “not applicable for Level C validation.”

Level B Data Validation

Data obtained using any analytical methods in the Level B Validation analytical categories will be validated in terms of meeting criteria for specific QA/QC factors such as holding times, blank spike analyses, and blank analyses. A separate discussion of each QA/QC factor under each analytical method will be presented in the CTO data validation report. The QA/QC factors used to validate data for QA/QC "Level B Validation" are presented below for each analytical category.

Organic Analyses

1. Sample management (sample preservation, handling, and transport; chain-of-custody; and holding times)
2. Method blanks
3. Blank spikes and laboratory control samples
4. Field QC samples (trip blanks (volatile organic compounds), equipment blanks, field blanks, field duplicates, and field triplicates)
5. Surrogate recovery
6. MS/MSD

Inorganic Analyses

1. Sample management (sample preservation, handling, and transport; chain-of-custody; and holding times)
2. Blanks (Calibration and Method blanks)
3. Blank spikes and LCSs
4. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
5. MS/MSD and Laboratory Duplicates
6. ICP serial dilution

5.2.3.4 LABORATORY REPORTS

Annotated laboratory reports with the appropriate data qualifiers and qualification codes as specified in the NAVFAC Pacific ER Program data validation procedures will be submitted as an appendix to the data validation report. An example is provided as Attachment II-A-7. Records

Copies of all documents generated by data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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7. Attachments

Attachment II-A-1: Acronyms and Abbreviations

Attachment II-A-2: Definition of Terms

Attachment II-A-3: Sample Cover Letter

Attachment II-A-4: Data Qualifier Reference Table

Attachment II-A-5: Qualification Code Reference Table

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Attachment II-A-7: Example Annotated Laboratory Report Volatile Organics Analysis Data Sheet

Attachment II-A-1
Acronyms and Abbreviations

ACRONYMS AND ABBREVIATIONS

Following is a list of acronyms and abbreviations that may be used in NAVFAC Pacific ER Program data validation reports and the data quality assessment reports.

%D	percent difference
%R	percent recovery
µg/kg	microgram per kilogram
µg/L	microgram per liter
4,4'-DDD	4,4'-dichlorodiphenyldichloroethane
4,4'-DDE	4,4'-dichlorodiphenyldichloroethylene
4,4'-DDT	4,4'-dichlorodiphenyltrichloroethane
AA	atomic absorption
ARRF	average relative response factor
BFB	bromofluorobenzene
BNA	base/neutral/acid
CCB	continuing calibration blank
CCC	calibration check compound
CCV	continuing calibration verification
CF	calibration factor
CLP	Contract Laboratory Program
COC	chain-of-custody
COD	chemical oxygen demand
CTO	contract task order
CVAA	cold vapor atomic absorption
DBCP	Dibromochloropropane
DCB	decachlorobiphenyl
DFTPP	decafluorotriphenylphosphine
DL	detection limit
DoD	Department of Defense
DOE	Department of Energy
DQAR	data quality assessment report
DUP	laboratory duplicate
DVP	data validation procedure
EB	equipment blank
EDB	ethylene dibromide
EDL	estimated detection limit
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
FB	field blank
GC	gas chromatography
GC/ECD	gas chromatography/electron capture detector
GC/ELCD	gas chromatography/electrolytic conductivity detector (Hall detector)
GC/FPD	gas chromatography/flame photometric detector
GC/MS	gas chromatography/mass spectrometry

GC/PID	gas chromatography/photoionization detector
GFAA	graphite furnace atomic absorption
GPC	gel permeation chromatography
Hg	mercury
HPLC	high-performance liquid chromatography
HRGC/HRMS	high resolution gas chromatography/high resolution mass spectrometry
HT	holding time
ICB	initial calibration blank
ICP	inductively coupled plasma
ICS	interference check sample
ICV	initial calibration verification
IDL	instrument detection limit
IR	infrared spectroscopy
IRP	installation restoration program
IS	internal standards
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
m/z	mass to charge ratio
MBAS	methyl blue active substance
mg/kg	milligram per kilogram
mg/L	milligram per liter
MS	matrix spike
MSA	method of standard addition
MSD	matrix spike duplicate
NFESC	Naval Facilities Engineering Services Center
ng/kg	nanogram per kilogram
OP	organophosphorus
PAH	polynuclear aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, comparability, completeness
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzodioxin
PCDF	polychlorinated dibenzofuran
PE	performance evaluation
PEM	performance evaluation mixture
PFK	perfluorokerosene
pg/g	picogram per gram
pg/L	picogram per liter
PQO	project quality objective
QA	quality assurance
QAC	quality assurance coordinator
QAPP	quality assurance project plan
QC	quality control
QSM	quality system manual

r	correlation coefficient
r^2	coefficient of determination
RF	response factor
RIC	reconstructed ion chromatogram
RL	reporting limit
RPD	relative percent difference
RRF	relative response factor
RRT	relative retention time
RSD	relative standard deviation
RT	retention time
s/n	signal to noise ratio
SDG	sample delivery group
SICP	selected ion current profiles
SOP	standard operating procedure
SOW	statement of work
SPCC	system performance check compound
SRM	standard reference material
SVOC	semivolatile organic compound
TB	trip blank
TCDD	tetrachlorodibenzodioxin
TCX	tetrachloro-m-xylene
TDS	total dissolved solids
TIC	tentatively identified compound
TOC	total organic carbon
TOX	total organic halides
TPHE	total petroleum hydrocarbons as extractables
UV/VIS	ultraviolet/visible
VOA	volatile organic analysis
VOC	volatile organic compound
VTSR	validated time of sample receipt
WDM	window defining mixture

Attachment II-A-2
Definition of Terms

DEFINITION OF TERMS

Calibration Curve	–	A plot of response versus concentration of standards.
CCB	–	Continuing Calibration Blank – a deionized water sample run every 10 samples designed to detect any carryover contamination.
CCV	–	Continuing Calibration Verification – a standard run every 10 samples to test instrument performance.
EDL	–	Estimated Detection Limit – The sample specific EDL is the concentration of a given analyte required to produce a signal with a peak height of at least 2.5 times the background signal level.
Field Blank	–	Field blanks are intended to identify contaminants that may have been introduced in the field through source water.
Field Duplicate	–	A duplicate sample generated in the field, not in the laboratory.
Findings	–	Any out-of-control, unacceptable, or out of criteria event which may impact the quality of the data or require corrective action.
GPC	–	Gel Permeation Chromatography – A sample clean-up technique that separates compounds by size and molecular weight. Generally used to remove oily materials from sample extracts.
Holding Time	–	The time from sample collection to sample analysis.
ICB	–	Initial Calibration Blank – the first blank standard run to confirm the calibration curve.
ICV	–	Initial Calibration Verification – the first standard run to confirm the calibration curve.
Initial Calibration	–	The establishment of a calibration curve with the appropriate number of standards and concentration range. The calibration curve plots instrument response versus concentration of standards.
IR	–	Infrared Spectroscopy.
IS	–	Internal Standards – compounds added to every VOA and BNA standard, blank, matrix spike duplicate, and sample extract at a known concentration, prior to instrumental analysis. Internal standards are used as the basis for quantitation of the target compounds.
Laboratory Duplicate	–	A duplicate sample generated in the laboratory.
MDL	–	Method Detection Limit – minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.
MS	–	Matrix Spike – introduction of a known concentration of analyte into a sample to provide information about the effect of the sample matrix on the extraction or digestion and measurement methodology.
m/z	–	The ratio of mass (m) to charge (z) of ions measured by GC/MS.

Post Digestion Spike	–	The addition of a known amount of standard after digestion. (Also identified as analytical spike or spike for furnace analysis).
Primary Analysis	–	One of two types of pesticide/PCB analysis by GC/EC techniques, the other being confirmation analysis. The primary analysis is used to establish the tentative identification of any pesticides/PCBs detected. The identification is confirmed in the confirmation analysis. If the two analyses are done simultaneously, either may be considered the primary analysis. Either may be used for quantitation if contract criteria are met.
QA	–	Quality Assurance – total program for assuring the reliability of data
QC	–	Quality Control – routine application of procedures for controlling the monitoring process.
RL	–	Reporting Limit – value specified by the client based on sensitivity requirements from project-specific action levels.
RPD	–	Relative Percent Difference (between matrix spike and matrix spike duplicate, duplicate laboratory control samples, or blank spikes)
Serial Dilution	–	A sample run at a specific dilution to determine whether any significant chemical or physical interferences exist due to sample matrix effects (ICP only).
SDG	–	Sample Delivery Group – defined by one of the following, whichever occurs first: • Case of field samples • Each 20 field samples within a case • Each 14-day calendar period during which field samples in a case are received, beginning with receipt of the first sample in the SDG
Level B Validation	–	Data validation is performed using sample results and QA/QC summaries (i.e., method blanks, LCS, MS/MSDs, surrogates, and serial dilutions). This level of data validation was previously identified as “Standard.”
Level C Data Validation	–	Data validation is performed using sample results and QA/QC summaries (including instrument performance, calibration, and internal standard data). This level of data validation was previously identified as “Cursory.”
Level D Data Validation	–	Data validation is performed using sample results, QA/QC summaries (including instrument performance, calibration, and internal standard data) and raw data associated to the sample results and QA/QC summaries. This level of data validation was previously identified as “Full.”

Attachment II-A-3
Sample Cover Letter

SAMPLE COVER LETTER

(Date)

(CTO Manager or designee) (company address) Dear ( ): Enclosed is Revision __ of the data validation reports for CTO (number) as follows: Semi-volatiles SDG S0221 SDG S0350 Pesticides/PCBs SDG S0201 Metals SDG S0221 SDG S0201 The specific sample identifications are listed in the Sample Identification Table(s). The data packages were reviewed according to the data validation procedures referenced in the introduction to each report.

Sincerely,

(Signature)
Data Validation Project Manager

Attachment II-A-4
Data Qualifier Reference Table

Table II-A-4-1: Data Qualifier Reference Table

Qualifier	Organics	Inorganics
U	The analyte was analyzed for, but was not detected above the method detection limit.	The analyte was analyzed for, but was not detected above the method detection limit.
J	The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
N	The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification."	Not applicable.
NJ	The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.	Not applicable.
UJ	The analyte was not detected above the method detection limit. However, the associated value is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.	The analyte was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and to meet quality control criteria. The presence or absence of the analyte cannot be verified.	The data are unusable. The sample results are rejected due to serious deficiencies in meeting the Quality Control (QC) criteria. The analyte may or may not be present in the sample.

Attachment II-A-5
Qualification Code Reference Table

Table II-A-5-1: Qualification Code Reference Table

Qualifier	Organics	Inorganics
H	Holding times were exceeded.	Holding times were exceeded.
S	Surrogate recovery was outside QC limits.	The sequence or number of standards used for the calibration was incorrect.
C	Calibration %RSD, r, r^2 or %D were noncompliant	Correlation coefficient is <0.995.
R	Calibration RRF was <0.05.	%R for calibration is not within control limits
B	Presumed contamination from preparation (method blank)	Presumed contamination from preparation (method) blank or calibration blank
L	Laboratory Control Sample/Laboratory Control Sample Duplicate %R or RPD was not within control limits	Laboratory Control Sample/Laboratory Control Sample Duplicate %R or RPD was not within control limits
Q	MS/MSD recovery was poor	MS/MSD recovery was poor.
E	MS/MSD or Duplicate RPD was high.	MS/MSD or Duplicate RPD or difference was high.
I	Internal standard performance was unsatisfactory	ICP ICS results were unsatisfactory.
A	Not applicable.	ICP Serial Dilution %D were not within control limits
M	Instrument Performance Check (BFB or DFTPP) was noncompliant	Not applicable.
T	Presumed contamination from trip blank.	Not applicable.
F	Presumed contamination from FB or ER.	Presumed contamination from FB or ER.
D	The analysis with this flag should not be used because another more technically sound analysis is available.	The analysis with this flag should not be used because another more technically sound analysis is available.
P	Instrument performance for pesticides was poor	Post Digestion Spike recovery was not within control limits
V	Unusual problems found with the data that have been described in the validation report where a description of the problem can be found.	Unusual problems found with the data that have been described in where a description of the problem can be found.

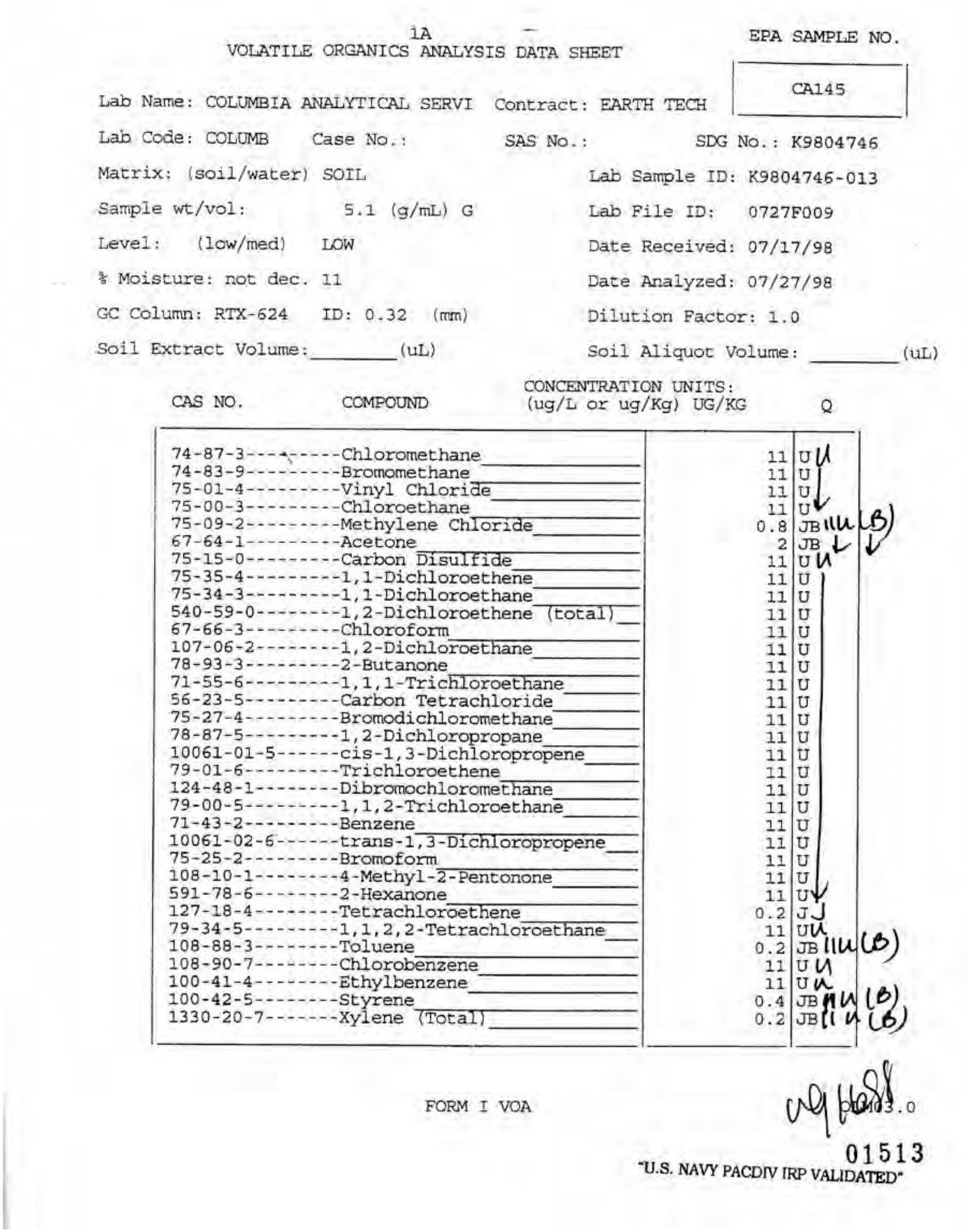
Attachment II-A-6
Sample Identification Table

Table II-A-6-1: Sample Identification Table

EPA Identification	Sample Identification	Lab Identification Number	COC Sample Number	Matrix
FB001	FB-BS04-E01-D10.0	2720-1	DA001	water
FB002	FB-BS04-B01-D10.0	2720-2	DA002	water
FB003	FB-BS04-B02-D10.0	2720-3	DA003	water
FB004	FB-SS01-S01-D0.5	2720-4	DA004	soil
FB005	FB-BS01-S01-D10.0	2720-5	DA005	soil
FB006	FB-SS02-S01-D0.5	2720-6	DA006	soil
FB007	FB-BS02-S01-D10.0	2720-7	DA007	soil
FB008	FB-BS02-D01-D10.0	2720-8	DA008	soil
FB009	FB-SS03-S01-D0.5	2720-9	DA009	soil
FB010	FB-BS03-S01-D10.0	2720-10	DA010	soil

Attachment II-A-7
Example Annotated Laboratory Report
Volatile Organics Analysis Data Sheet

EXAMPLE ANNOTATED LABORATORY REPORT
VOLATILE ORGANICS ANALYSIS DATA SHEET



1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.
CA145

Lab Name: COLUMBIA ANALYTICAL SERVI Contract: EARTH TECH
Lab Code: COLUMB Case No.: SAS No.: SDG No.: K9804746
Matrix: (soil/water) SOIL Lab Sample ID: K9804746-013
Sample wt/vol: 5.1 (g/mL) G Lab File ID: 0727F009
Level: (low/med) LOW Date Received: 07/17/98
% Moisture: not dec. 11 Date Analyzed: 07/27/98
GC Column: RTX-624 ID: 0.32 (mm) Dilution Factor: 1.0
Soil Extract Volume:________(uL) Soil Aliquot Volume: ________(uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q	
74-87-3	Chloromethane	11	U	U
74-83-9	Bromomethane	11	U	
75-01-4	Vinyl Chloride	11	U	
75-00-3	Chloroethane	11	U	↓
75-09-2	Methylene Chloride	0.8	JB	11U (B)
67-64-1	Acetone	2	JB	↓ ↓
75-15-0	Carbon Disulfide	11	U	U
75-35-4	1,1-Dichloroethene	11	U	
75-34-3	1,1-Dichloroethane	11	U	
540-59-0	1,2-Dichloroethene (total)	11	U	
67-66-3	Chloroform	11	U	
107-06-2	1,2-Dichloroethane	11	U	
78-93-3	2-Butanone	11	U	
71-55-6	1,1,1-Trichloroethane	11	U	
56-23-5	Carbon Tetrachloride	11	U	
75-27-4	Bromodichloromethane	11	U	
78-87-5	1,2-Dichloropropane	11	U	
10061-01-5	cis-1,3-Dichloropropene	11	U	
79-01-6	Trichloroethene	11	U	
124-48-1	Dibromochloromethane	11	U	
79-00-5	1,1,2-Trichloroethane	11	U	
71-43-2	Benzene	11	U	
10061-02-6	trans-1,3-Dichloropropene	11	U	
75-25-2	Bromoform	11	U	
108-10-1	4-Methyl-2-Pentonone	11	U	
591-78-6	2-Hexanone	11	U	↓
127-18-4	Tetrachloroethene	0.2	J	J
79-34-5	1,1,2,2-Tetrachloroethane	11	U	U
108-88-3	Toluene	0.2	JB	11U (B)
108-90-7	Chlorobenzene	11	U	U
100-41-4	Ethylbenzene	11	U	U
100-42-5	Styrene	0.4	JB	11U (B)
1330-20-7	Xylene (Total)	0.2	JB	11U (B)

FORM I VOA OLM03.0

01513

"U.S. NAVY PACDIV IRP VALIDATED"

Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of volatile organic data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography/mass spectrometry (GC/MS) volatile data.

4. Procedure

This procedure addresses the validation of volatile organic data obtained using U.S. Environmental Protection Agency Method Solid Waste (SW)-846 8260 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form V: Instrument Performance Check Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: Internal Standard Summary Form

Level C data validation consists of review of summary forms only, whereas Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport, chain of custody (COC), and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Water samples must be preserved with hydrochloric acid at or below a pH of 2 and refrigerated at above freezing to 6 degrees Celsius (°C).
2. Soil samples collected in volatile organic analysis (VOA) vials or coring devices must be refrigerated at or above freezing to 6°C. If the samples are to be analyzed after the 48-hour holding time, the laboratory must preserve the samples with sodium bisulfate or methanol or water or freeze upon receipt in accordance with SW-846 Method 5035.
3. If the analyzed aqueous VOA vial contains air bubbles or headspace, is cracked, or has a cracked cap, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” The sample data may be qualified as unusable, “R,” if the container damage is extensive or improper sealing is identified.
4. VOA vials are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C, but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature of receipt is greater than or equal to 15°C, positive values shall be flagged as estimated “J” and nondetects as unusable “R.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.
5. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

6. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC form for legibility and check that all volatile analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory sample results form (Form I [or equivalent]) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for volatiles but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times for volatile organics are measured from the time of collection (as shown on the COC) to the time of sample analysis (as shown on the sample results form and instrument performance check summary form [Forms I and V (or equivalent)]). Water samples must be preserved with hydrochloric acid and refrigerated at above freezing to 6°C. Preserved water samples shall be analyzed within 14 days from the collection date. If there is no indication of chemical preservation, assume samples are unpreserved. For unpreserved water samples, the holding time is 7 days from date collected for aromatic volatiles and 14 days from date collected for non-aromatic volatiles. Soil samples collected in VOA vials or coring devices that are unpreserved must be refrigerated at above freezing to 6°C and analyzed within 48 hours from the collection date. Soil samples that are preserved with sodium bisulfate or methanol, or frozen upon laboratory receipt shall be analyzed within 14 days from the collection date.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.

2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a preserved water sample has a holding time of more than 28 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

4.2 GC/MS INSTRUMENT PERFORMANCE CHECK

Level C and Level D:

GC/MS instrument performance checks or tune checks are performed to ensure mass resolution, identification, and to some degree, sensitivity. These criteria are not sample specific. Conformance is determined using standard reference materials; therefore, these criteria should be met in all circumstances.

The analysis of the instrument performance check solution must be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The instrument performance check, bromofluorobenzene (BFB) for volatile analysis, must meet the ion abundance criteria given below.

Table II-B-1: Ion Abundance Criteria – BFB

m/z	Ion Abundance Criteria
50	15.0–40.0% of m/z 95
75	30.0–60.0% of m/z 95
95	Base peak, 100% relative abundance
96	5.0–9.0% of m/z 95
173	Less than 2.0% of m/z 174
174	Greater than 50.0% of m/z 95
175	5.0–9.0% of m/z 174
176	Greater than 95.0% but less than 101.0% of m/z 174
177	5.0–9.0% of m/z 176

%	percent
m/z	mass-to-charge ratio

Check that all sample runs are associated with an injection. Make certain that a BFB performance check is present for each 12-hour period samples are analyzed (Form V [or equivalent]). Verify that all samples were analyzed within 12 hours of BFB injection.

If ion abundance criteria are not met, professional judgment may be applied to determine to what extent the data may be utilized. The most important factors to consider are the empirical results that are relatively insensitive to location on the chromatographic profile and type of instrumentation; therefore, the critical ion abundance criteria for BFB are the mass-to-charge ratio (m/z) 95/96, 174/175, 174/176, and 176/177 ratios. The relative abundance of m/z 50 and 75 are of lesser importance. Use professional judgment when samples are analyzed beyond the 12-hour time limit.

Decisions to use analytical data associated with BFB instrument performance checks not meeting requirements should be noted in the data validation report.

Level D:

Verify by recalculating from the quantitation reports, mass spectra, and chromatograms that the mass assignment is correct and that the mass listing is normalized to the specified m/z. If transcription errors are discovered on the Form V (or equivalent), request a resubmittal from the laboratory. Validate the data using the criteria outlined above.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the volatile target compound list.

4.3.1 Initial Calibration

Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing an acceptable calibration curve.

Level C and Level D:

1. Evaluate the average relative response factors (RRFs) for all target compounds by checking Form VI (or equivalent).
2. If any of the volatile target compounds listed in Table II-B-2 below has an average RRF of less than 0.01 except for 1,4-dioxane (≤0.005) or any of the other volatile target compounds has an average RRF of less than 0.05, flag positive results for that compound as estimated "J" and nondetects as unusable "R" in associated samples.

Table II-B-2: Volatile Compounds Exhibiting Poor Response

Acetone	1,2-Dibromo-3-chloropane
2-Butanone	Isopropylbenzene
Carbon disulfide	Methyl acetate
Chloroethane	Methylene chloride
Chloromethane	Methylcyclohexane
Cyclohexane	Methyl tert-butyl ether
1,2-Dibromoethane	trans-1,2-Dichloroethene
Dichlorodifluoromethane	4-Methyl-2-pentanone
1,2-Dichloropropane	2-Hexanone
cis-1,2-Dichloroethene	Trichlorofluoromethane
1,4-Dioxane	1,1,2-Trichloro-trifluoromethane

3. Check Form VI (or equivalent) and evaluate the percent relative standard deviation (%RSD) for all target compounds. If any volatile target compound has a %RSD of greater than 15 percent, flag detects for the affected compounds as "J" and nondetects as "UJ" in the associated samples that correspond to that initial calibration.

Level D:

1. Verify the files reported on Form VI (or equivalent) against the quantitation reports, mass spectra, and chromatograms. If the files do not match, the RRFs reported are likely to be

from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.

2. Recalculate the average RRFs and %RSDs reported on Form VI (or equivalent) for one compound per internal standard (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in all samples associated with the initial calibration.

Level D:

1. Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data. Continuing calibration establishes the 12-hour relative response factors on which the quantitations are based and checks satisfactory performance of the instrument on a day-to-day basis.

Level C and Level D:

1. Continuing calibration standards containing both target compounds and system monitoring compounds must be analyzed every 12 hours during operation. Evaluate the continuing RRFs on Form VII (or equivalent).
2. Ensure that the average RRFs reported on Form VII (or equivalent) correspond to the average RRFs reported on Form VI (or equivalent) for the corresponding initial calibration.
3. If any of the volatile target compounds listed in Table II-B-2 has an average RRF of less than 0.01 except for 1,4-dioxane (≤0.005) or any of the other volatile target compounds has an average RRF of less than 0.05, flag positive results for that compound as estimated “J” and nondetects as unusable “R” in associated samples.

4. If any volatile target compound has a %D between the initial calibration average RRF and continuing calibration RRFs outside 20 percent, flag all detects as “J” and all nondetects as “UJ” in all associated samples that correspond to that continuing calibration.

5. An ending continuing calibration is required by DoD QSM Appendix B (an ending continuing calibration is not required by the method) and professional judgment should be used in qualifying associated data when the %D is outside 50 percent.

Level D:

1. Verify the file reported on Form VII (or equivalent) against the raw data for the continuing calibration. If the file does not match, the RRFs reported are likely to be from another continuing calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the reported RRFs and %Ds reported on Form VII (or equivalent) for one compound per internal standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias associated with the data, or if the problem is an isolated occurrence not affecting other data. Results may not be corrected by subtracting any blank values.

Level C and Level D:

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each 12-hour time period on each GC/MS system used to analyze VOA samples. Each sample must have an associated method blank. Medium level samples (samples that are known to have high concentrations of compounds) should have an associated methanol extraction blank. Qualify positive results in samples with no method blank as unusable “R.” Nondetects do not require qualification.
2. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.
3. If a compound is found in the blank, but not in the associated sample, no action is taken.
4. Any compound, other than those listed in Table II-B-3, detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Compounds listed in Table II-B-3 shall be qualified when the sample concentration is less than 2× the LOQ and the blank concentration is less than, greater than, or equal to 2× LOQ. Care should be taken to factor in the percent moisture when comparing detects in the

sample and the method blank. The applicable review qualifier(s) are summarized in Table II-B-4.

Table II-B-3: Common Laboratory Contaminants

1. Methylene chloride
2. Acetone
3. 2-Butanone

Table II-B-4: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ* and blank result is <, > or = LOQ*	Leave as reported	U
≥LOQ*, blank result is <LOQ*	Leave as reported	None
≥LOQ*, blank result is >LOQ* and sample result < blank result	Leave as reported	Use professional judgment
≥LOQ*, blank result is >LOQ* and sample result ≥ blank result	Leave as reported	Use professional judgment
≥LOQ* and blank result is = LOQ*	Leave as reported	Use professional judgment

* 2x LOQ for common laboratory contaminants

5. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the planning documents may be applied to qualify associated sample results. Otherwise qualify sample results as non-detect “U” when the sample concentration is less than or equal to 10 times the blank concentration (10× rule) for the compounds listed in Table II-B-3 and tentatively identified compounds (TICs). For all other compounds, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).

6. If gross contamination exists in the blanks (i.e., saturated peaks by GC/MS), all compounds affected shall be flagged as unusable “R” due to interference in all samples affected and this shall be noted in the data validation comments.

7. If target compounds other than common laboratory contaminants are found at low levels in the blank(s), it may be indicative of a problem at the laboratory and shall be noted in the data validation report.

8. Additionally, there may be instances where little or no contamination was present in the associated blanks, but qualification of the sample was deemed necessary. Contamination introduced through dilution water is one example. Although it is not always possible to determine, instances of this occurring can be detected when contaminants are found in the diluted sample result, but are absent in the undiluted sample result. It may be impossible to verify this source of contamination; however, if the reviewer determines that the contamination is from a source other than the sample, the data should be qualified The sample value shall be reported as a nondetect and the reason shall be documented in the data validation report. Qualification of the data will be performed as given in Table II-B-4.

Level D:

1. Verify all target compound and TIC detects found in the method blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid or the tentative identity is in error, request for a corrected Form I for the method blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B. if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one or more spike recoveries per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

Q_D = Quantity determined by analysis

Q_A = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SYSTEM MONITORING COMPOUNDS (SURROGATE SPIKES)

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects due to such factors as interference and high concentrations of compounds. Because the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. These procedures shall be followed:

Level C and Level D:

1. Sample and blank surrogate recoveries for volatiles must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).
   a. If one surrogate for the VOA fraction is out of specification, then a re-analysis must be reported even though surrogate results are outside the criteria. (Note: When unacceptable surrogate recoveries are followed by successful re-analyses, the laboratory is required to report only the successful run. The laboratory does not have to re-analyze a sample if a MS/MSD was performed on the sample with out-of-control surrogate results showing the same matrix effects.) Medium level soils must be re-extracted and re-analyzed if the surrogate recoveries are outside the criteria.
   b. The laboratory has failed to perform satisfactorily if surrogate recoveries are out of specification with no evidence of re-purging. The non-surrogate recoveries shall be documented in the data validation report.
2. If surrogate spike recoveries are out of specification, samples will be qualified as follows:
   a. If any surrogate is below the lower acceptance limit but has a recovery greater than or equal to 10 percent, qualify positive results as estimated “J” and nondetects as estimated “UJ.”
   b. If any surrogate is above the upper acceptance limit, qualify detects in the sample as estimated “J.” Compounds with nondetects should not be qualified.

3. If any surrogate in a fraction shows less than 10 percent recovery, flag detects for that fraction as estimated "J," and nondetects for the fraction as unusable "R."
4. In the special case of blank analysis with surrogates out of specification, the reviewer must give special consideration to the validity of associated sample data. The basic concern is whether the blank problems represent an isolated problem with the blank alone, or whether there is a fundamental problem with the analytical process. For example, if the samples in the batch show acceptable surrogate recoveries, the reviewer may determine the blank problem to be an isolated occurrence for which no qualification of the data is required.
5. Surrogates may be reported as "diluted out" (D), if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram and quantitation report may be necessary to determine that surrogates are truly "diluted out."

Level D:

To verify that the surrogate percent recovery was calculated and reported correctly using the following equation, recalculate all surrogate recoveries per matrix (and any surrogate that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

Q_D = Quantity determined by analysis

Q_A = Quantity added to samples/blanks

If transcription errors are discovered on Form II (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

Level C and Level D:

The laboratory must spike and analyze an MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and RPD for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as estimated “J.”
6. If the RPDs between MS and MSD results are greater than 20 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than two times the spike concentration or diluted by more than a factor of 2 should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of this procedure are trip blanks, equipment blanks, field blanks, field duplicates, and field triplicates.

4.8.1 Trip Blanks

Volatile organic parameters detected in trip blanks indicate the possibility of contamination of site samples or cross-contamination between site samples due to sample handling and transport while in the cooler.

One trip blank shall accompany each cooler containing samples to be analyzed for volatile organics. Each trip blank shall be analyzed for all volatile organic parameters for which the associated samples are analyzed. If a cooler contains multiple trip blanks, all samples contained in the cooler shall be associated with the results from all trip blanks contained in the cooler.

Level C and Level D:

1. Check that all coolers containing samples to be analyzed for volatile organics contained a trip blank that was also analyzed for volatile organics. If a cooler requiring a trip blank did not have an associated trip blank, no qualification of the samples transported in the cooler is necessary, but the incident shall be discussed in the data validation report.
2. If volatile organic compounds are detected in the trip blanks, the procedure for the qualification of associated sample results using validated and/or qualified trip blank results is identical to the criteria outlined in Section 4.4 of this procedure.

Level D:

1. Verify all target compound and TIC detects found in the trip blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and verify the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or the tentative identity is in error, request for a corrected Form I (or equivalent) for the trip blank from the laboratory.

3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.8.2 Equipment Blanks and Field Blanks

1. Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.
2. A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.
3. If volatile organic compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group (SDG).
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to micrograms per liter (µg/L) from milligrams per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method and trip blank results in order to account for laboratory contamination.

Level D:

1. Verify all target compound and TIC detects found in the equipment blanks and field blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I (or equivalent) for the equipment blank or field blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.8.3 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

1. Verify all target compound and TIC detects found in the field duplicates and/or field triplicates against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I for the field duplicates from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.9 INTERNAL STANDARDS PERFORMANCE

Internal standards performance criteria ensure that GC/MS sensitivity and response are stable during every analytical run.

Level C and Level D:

1. If an internal standards area count for a sample is outside –50 percent or +100 percent of the area for the initial calibration midpoint standard:
   a. Positive results for compounds quantitated using an internal standards area count greater than 100 percent should be qualified as estimated “J.” Nondetected compounds should not be qualified.

b. Compounds quantitated using an internal standards area count less than 50 percent should be qualified as estimated “J” for detects and estimated “UJ” for nondetects.

c. If extremely low area counts are reported (less than 20 percent of the area for associated standards), detected compounds should be qualified as estimated “J” and nondetected target compounds should then be qualified as unusable “R.”

2. If an internal standards retention time (RT) varies by more than 10 seconds from the RT of the initial calibration midpoint standard, the nondetected target compounds should be qualified as unusable “R” at Level C validation. A Level D validation examination of the raw data should be recommended to the CTO Manager. The chromatographic profile for that sample must be examined to determine if any false positives or negatives exist. For shifts of a large magnitude, the reviewer may consider partial or total rejection of the data for that sample fraction. Positive results should be qualified as “NJ” if the mass spectral criteria are met.

Level D:

1. Verify the internal standard areas reported on Form VIII (or equivalent) from the raw data for at least one sample per SDG, and verify internal standard areas for samples that were qualified due to out-of-control internal standard areas. If errors are discovered between the raw data and the Form VIII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.10 TARGET COMPOUND IDENTIFICATION

The objective of the criteria for GC/MS qualitative analysis is to minimize the number of erroneous identifications of target compounds. An erroneous identification can either be false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The identification criteria can be applied more easily in detecting false positives than false negatives. More information is available for false positives due to the requirement for submittal of data supporting positive identifications. However, negatives, or nondetected compounds, represent an absence of data and are therefore more difficult to assess. One example of detecting false negatives is the not reporting of a target compound that is reported as a TIC.

Level C:

Target compound identification is not evaluated for Level C validation since it requires the interpretation of mass spectral raw data.

Level D:

The following criteria should be followed when evaluating raw data.

1. The relative retention times (RRTs) must be within ± 0.06 RRT units of the standard RRT.
2. Mass spectra of the sample compound and a current laboratory-generated standard (i.e., the mass spectrum from the associated calibration standard) must match according to the following criteria:

a. All ions present in the standard mass spectrum at a relative intensity greater than 10 percent must be present in the sample spectrum.

b. The relative intensities of these ions must agree within ± 20 percent between the standard and sample spectra. (Example: For an ion with an abundance of 50 percent in the standard spectrum, the corresponding sample ion abundance must be between 30 percent and 70 percent.)

c. Ions present at greater than 10 percent in the sample mass spectrum, but not present in the standard spectrum, must be considered and accounted for.

d. The application of qualitative criteria for GC/MS analysis of target compounds requires professional judgment. It is up to the reviewer's discretion to obtain additional information from the laboratory and CTO Manager. If it is determined that incorrect identifications were made, all such data should be qualified as not detected "U" or unusable "R."

e. Professional judgment must be used to qualify the data if it is determined that cross-contamination has occurred. Any changes made to the reported compounds or concerns regarding target compound identifications should be clearly indicated in the data validation report.

4.11 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C and Level D:

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately 2× but not more than four times the current reported DL. Qualify nondetects as unusable "R."
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. Verify that reported limits for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If not, qualify the detected compound that required dilution as "J" and document the event in the data validation report.

Level D:

The compound quantitation must be evaluated for all detects by evaluating the raw data. Compound concentrations must be calculated based on the internal standards associated with that compound, as listed in the following equation. Quantitation must be based on the quantitation ion (m/z) specified in the analytical method for both the internal standards and target compounds. The compound quantitation must be based on the RRF from the appropriate ICAL standard.

Low Water

$$\mu g/L = \frac{A_x \times I_s \times D_f}{A_{is} \times ARRF \times V_o}$$

Where:

A_x = area of characteristic ion (extracted ion current profile) for compound being measured

I_s = amount of internal standard added (nanogram)

D_f = dilution factor

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

ARRF = average relative response factor for compound being measured

V_o = volume of water purged (milliliter [mL])

Low Soil/Sediment

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s}{A_{is} \times ARRF \times W_s \times D}$$

Where:

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

ARRF = Relative response factor from the heated purge of the initial calibration standard

W_s = Weight of sample added to the purge tube, in grams (g)

D = 100 – % moisture
100

Medium Soil/Sediment

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s \times V_t \times 1{,}000 \times D_f}{A_{is} \times ARRF \times V_a \times W_s \times D}$$

Where:

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

V_t = Total volume of the methanol extract in mL. Note: This volume is typically 10 mL, even though only 1 mL is transferred to the vial

ARRF = Average relative response factor from the ambient temperature purge of the initial calibration standard

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

W_s = Weight of soil/sediment extracted, in grams (g)

D_f = Dilution factor. The dilution factor for analysis of soil/sediment samples for volatiles by medium level method is defined as:

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

The dilution factor is equal to 1.0 in all cases other than those requiring dilution of the sample methanol extract (V_t). The factor of 1,000 in the numerator converts the value of V_t from mL to µL.

If discrepancies are discovered in the quantitation, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample, the laboratory must conduct a mass spectral search of the spectral library and report the possible identity for up to 30 of the largest volatile fraction peaks that are not system monitoring compounds (surrogates), internal standards, or target compounds, but which have area or height greater than 10 percent of the area or height of the nearest internal standard. TIC results are reported for each sample on the Organic Analyses Data Sheet (Form I VOA-TIC [or equivalent]).

Level C and Level D:

1. All TIC results should be qualified "NJ," tentatively identified with approximated concentrations.
2. The reviewer should be aware of common laboratory artifacts and their sources such as siloxane compounds, which indicate capillary column degradation, and carbon dioxide which indicates a possible air leak in the system. These may be qualified as unusable "R."
3. If a target compound is identified as a TIC by non-target library search procedures, the reviewer should request that the laboratory recalculate the result using the proper quantitation ion.
4. TIC results that are not above the 10× level in the blank should be qualified as unusable, "R." (Dilutions and sample size must be taken into account when comparing the amounts present in blanks and samples.)

5. The reviewer may elect to report all similar compounds as a total (e.g., all alkanes may be summarized and reported as total hydrocarbons).

Level D:

Check each TIC for each sample using the following criteria.

1. Major ions (greater than 10 percent relative intensity) in the reference spectrum should be present in the sample spectrum.
2. The relative intensities of the major ions should agree within ± 20 percent between the sample and the reference spectra.
3. Molecular ions present in the reference spectrum should be present in the sample spectrum.
4. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination, interference, or co-elution of additional TIC or target compounds.
5. When the above criteria are not met, but in the technical judgment of the data reviewer or mass spectral interpretation specialist, the identification is correct, the data validator may report the identification.
6. Since TIC library searches often yield several candidate compounds having a close matching score, all reasonable choices must be considered. The reviewer may use judgment to change the reported tentative identity.

5. Records

A Form I or equivalent that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. On-line updates at: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for GC/MS Semivolatile Organics by SW-846 8270 (Full Scan and SIM)

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of semivolatile organic data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratorie*s (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography/mass spectrometry (GC/MS) semivolatile data.

4. Procedure

This procedure addresses the validation of semivolatile organic data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 8270 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form V: Instrument Performance Check Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: Internal Standard Summary Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Samples are to be shipped in coolers that are maintained at above freezing to 6 degrees Celsius (°C). If the temperature exceeds 6°C but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.
2. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all semivolatile analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s)

can be determined. Conversely, samples that were analyzed for semivolatiles, but were not requested should also be noted.

2. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times for semivolatile organics are measured from the time of collection (as shown on the COC) to the time of sample extraction and from the time of sample extraction to the time of sample analysis (as shown on the Form I). Samples and extracts must be stored and refrigerated at above freezing to 6°C until the time of analysis.

Water samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 7 days of collection and analyzed within 40 days of extraction.

Soil samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 14 days of collection and analyzed within 40 days of extraction.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a non-water sample has a holding time of more than 14 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

4.2 GC/MS INSTRUMENT PERFORMANCE CHECK (FULL SCAN)

Level C and Level D:

GC/MS instrument performance checks or tune checks are performed for the Full scan analyses to ensure mass resolution, identification, and to some degree, sensitivity. Instrument performance checks are not required for samples analyzed by selected ion monitoring (SIM). These criteria are not sample specific. Conformance is determined using standard materials; therefore, these criteria should be met in all circumstances.

The analysis of the instrument performance check solution must be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The instrument performance check, decafluorotriphenylphosphine (DFTPP) for semivolatile analysis, must meet the ion abundance criteria given below.

Table II-C-1: Ion Abundance Criteria – DFTPP (SW-846 8270C)

m/z	Ion Abundance Criteria
51	30.0–60.0% of m/z 198
68	Less than 2.0% of m/z 69
70	Less than 2.0% of m/z 69
127	40.0–60.0% of m/z 198
197	Less than 1.0% of m/z 198
198	Base peak, 100% relative abundance
199	5.0–9.0% of m/z 198
275	10.0–30.0% of m/z 198
365	Greater than 1.0% of m/z 198
441	Present, but less than m/z 443
442	Greater than 40.0% of m/z 198
443	17.0–23.0% of m/z 442

%	percent
m/z	mass-to-charge ratio

Table C-II-2: Ion Abundance Criteria – DFTPP (SW-846 8270D)

m/z	Ion Abundance Criteria
51	10.0–80.0% of m/z 198
68	Less than 2.0% of m/z 69
70	Less than 2.0% of m/z 69
127	10.0–80.0% of m/z 198
197	Less than 2.0% of m/z 198
198	Base peak, 100% relative abundance
199	5.0–9.0% of m/z 198
275	10.0–60.0% of m/z 198
365	Greater than 1.0% of m/z 198
441	Present, but less than 24.0% m/z 442
442	Greater than 50.0% of m/z 198
443	15.0–24.0% of m/z 442

Check that all sample runs are associated with an injection. Make certain that a DFTPP performance check is present for each 12-hour period samples are analyzed (Form V [or equivalent]). Verify that all samples were analyzed within 12 hours of DFTPP injection.

If ion abundance criteria are not met, professional judgment may be applied to determine to what extent the data may be utilized. The most important factors to consider are the empirical results that are relatively insensitive to location on the chromatographic profile and type of instrumentation; therefore, the critical ion abundance criteria for DFTPP are the mass to charge (m/z) ratios for 198/199 and 442/443. The relative abundances for m/z 68, 70, 197, and 441 are also very important.

The relative abundances of m/z 51, 127, 275, and 365 are of lesser importance. For example, if the relative abundance of m/z 365 is zero, minimum detection limits may be affected. However, if m/z 365 is present, but less than the 1.0 percent minimum abundance criteria, the deficiency is not as serious. Use professional judgment when samples are analyzed beyond the 12-hour time limit.

DFTPP should also be used to assess GC column performance and injection port inertness. Degradation of 4,4'-dichlorodiphenyltrichloroethane to 4,4'-dichlorodiphenyldichloroethane and 4,4'-dichlorodiphenyldichloroethylene should not exceed 20 percent. Benzidine and pentachlorophenol should be present at their normal responses and should not exceed a tailing factor of 2 using the equation presented in EPA SW-846 8270D (or most current version). Decisions to use analytical data associated with DFTPP instrument performance checks not meeting requirements should be noted in the data validation report.

Level D:

Verify by recalculating from the raw data (mass spectral listing) that the mass assignment is correct and that the mass listing is normalized to the specified m/z. If transcription or rounding errors are discovered on the Form V (or equivalent), request a resubmittal from the laboratory. Validate the data using the criteria outlined above.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the semivolatile target compound list for both Full Scan and SIM analyses.

4.3.1 Initial Calibration

Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing an acceptable calibration curve for both Full Scan and SIM analyses.

Level C and Level D:

1. Evaluate the average relative response factors (RRFs) for all target compounds by checking Form VI (or equivalent).
2. If any of the semivolatile target compounds listed in Table C-II-3below has an average RRF of less than 0.01 or any other semivolatile target compound has an average RRF of less than 0.05, flag positive results for that compound as estimated “J” and nondetects as unusable “R” in associated samples.

Table C-II-3: Semivolatile Compounds Exhibiting Poor Response

2,2’-Oxybis-(1-chloropropane)	Benzaldehyde
4-Chloroaniline	4-Nitroaniline
Hexachlorobutadiene	4,6-Dinitro-2-methylphenol
Hexachlorocyclopentadiene	N-Nitrosodiphenylamine
2-Nitroaniline	3,3’-Dichlorobenzidine
3-Nitroaniline	1,1’-Biphenyl
2,4-Dinitrophenol	Dimethylphthalate
4-Nitrophenol	Diethylphthalate

Acetophenone	1,2,4,5-Tetrachlorobenzene
Caprolactam	Carbazole
Atrazine	Butylbenzylphthalate
Di-n-butylphthalate	Di-n-octylphthalate
Bis(2-ethylhexyl)phthalate	

3. Check Form VI (or equivalent) and evaluate the percent relative standard deviation (%RSD) for all target compounds. If any semivolatile target compound has a %RSD of greater than 15 percent, flag detects for the affected compounds as “J” and nondetects as “UJ” in the associated samples that correspond to that initial calibration.

Level D:

1. Verify the files reported on Form VI (or equivalent) against the quantitation reports, mass spectra, and chromatograms. If the files do not match, the RRFs reported are likely to be from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the average RRFs and %RSDs reported on Form VI (or equivalent) for one compound per internal standard from the raw data (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in all samples associated with the initial calibration.

Level D:

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

The continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis for both Full Scan and SIM analyses.

Level C and Level D:

1. Continuing calibration standards containing both target compounds and system monitoring compounds must be analyzed every 12 hours during operation. Evaluate the continuing RRFs on Form VII (or equivalent).
2. Ensure that the average RRFs reported on Form VII (or equivalent) correspond to the average RRFs reported on Form VI (or equivalent) for the corresponding initial calibration.
3. If any of the semivolatile target compounds listed in Table C-II-3 has an average RRF of less than 0.01 or any other semivolatile target compound has an average RRF of less than 0.05, flag positive results for that compound as estimated "J" and nondetects as unusable "R" in associated samples.
4. If any semivolatile target compound has a %D between the initial calibration average RRF and continuing calibration RRFs outside 20 percent, flag all detects as "J" and all nondetects as "UJ" in all associated samples that correspond to that continuing calibration.
5. An ending continuing calibration is required by DoD QSM Appendix B (an ending continuing calibration is not required by the method) and professional judgment should be used in qualifying associated data when the %D is outside 50 percent.

Level D:

1. Verify the file reported on Form VII (or equivalent) against the raw data for the continuing calibration. If the file does not match, the RRFs reported are likely to be from another continuing calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the reported RRFs and %Ds reported on Form VII (or equivalent) for one compound per internal standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias on the data, or if the problem is an isolated occurrence not affecting other data. Results may not be corrected by subtracting any blank values.

Level C and Level D:

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable "R." Nondetects do not require qualification.
2. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.

3. If a compound is found in the blank, but not in the associated sample, no action is taken.
4. Compounds that are detected in both the sample and the associated blank with the exception of bis(2-ethylhexylphthalate) shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Bis(2-ethylhexylphthalate) shall be qualified when the sample concentration is less than five times (5×) the LOQ and the blank concentration is less than, greater than, or equal to 5× LOQ. Care should be taken to factor in the percent moisture when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table C-II-4.

Table C-II-4: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ* and blank result is <, > or = LOQ*	Leave as reported	U
≥ LOQ*, blank result is < LOQ*	Leave as reported	None
≥ LOQ*, blank result is > LOQ* and sample result < blank result	Leave as reported	Use professional judgment
≥ LOQ*, blank result is > LOQ* and sample result ≥ blank result	Leave as reported	Use professional judgment
≥ LOQ* and blank result is = LOQ*	Leave as reported	Use professional judgment

*5x LOQ for bis(2-ethylhexylphthalate)

In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 10 times the blank concentration (10× rule) for the phthalates listed in Table C-II-5 and tentatively identified compounds (TICs). For all other compounds, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5× the blank concentration (5× rule).

Table C-II-5: Phthalates

Dimethylphthalate
Diethylphthalate
Di-n-butylphthalate
Butylbenzylphthalate
Bis(2-ethylhexylphthalate)
Di-n-octylphthalate

5. If gross contamination exists in the blanks (i.e., saturated peaks by GC/MS), all compounds affected shall be flagged as unusable “R” due to interference in all samples affected and this shall be noted in the data validation comments.
6. If target compounds other than common laboratory contaminants are found at low levels in the blank(s), it may be indicative of a problem at the laboratory and shall be noted in the data validation report.
7. Additionally, there may be instances where little or no contamination was present in the associated blanks, but qualification of the sample was deemed necessary. Contamination

introduced through dilution water is one example. Although it is not always possible to determine, instances of this occurring can be detected when contaminants are found in the diluted sample result, but are absent in the undiluted sample result. It may be impossible to verify this source of contamination; however, if the reviewer determines that the contamination is from a source other than the sample, the data should be qualified. The sample value shall be reported as a nondetect and the reason shall be documented in the data validation report.

Level D:

1. Verify all target compound and TIC detects found in the method blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid or the tentative identity is in error, request for a corrected Form I for the method blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent difference (RPDs) between LCS and LCSD results are above the control limits (use the MS/MSD RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one or more spike recoveries per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SYSTEM MONITORING COMPOUNDS (SURROGATE SPIKES)

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects because of factors such as interferences and high concentrations of compounds. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. The following procedures shall be followed:

Level C and Level D:

1. Sample and blank surrogate recoveries for semivolatiles must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).
2. If two or more surrogates in a base/neutral fraction or two or more surrogates in an acid fraction are out of specification, or if at least one surrogate has a recovery of less than 10 percent, then the sample should be re-analyzed though surrogate results still could be outside the criteria. (Note: When unacceptable surrogate recoveries are followed by successful re-analyses, the laboratories are required to report only the successful run unless the re-analyses were performed outside the holding times. Laboratories do not have to perform a re-analysis if a matrix spike/matrix spike duplicate was performed on the sample with out-of-control surrogate results showing the same matrix effects.)
3. The laboratory has failed to perform satisfactorily if surrogate recoveries are out of specification with no evidence of re-analysis. The non-surrogate recoveries shall be documented in the data validation report.

4. If two or more surrogates in the base/neutral fraction or two or more surrogates in the acid fraction are less than lower acceptance limit, but have a recovery greater than or equal to 10 percent, qualify positive results for that fraction as estimated "J" and nondetects as estimated "UJ." (Note that all phenols pertain to the acid fraction; all remaining compounds correspond to the base neutral fraction.)
5. If any surrogate in a fraction shows less than 10 percent recovery, qualify positive results for that fraction as estimated "J," and nondetects for the fraction as unusable "R."
6. If two or more surrogates in either base/neutral or acid-faction have a recovery greater than the upper acceptance limit, detected compounds in that fraction are qualified "J." Nondetects should not be qualified.
7. No qualification with respect to surrogate recovery is placed on data unless at least two surrogates in the semivolatile fraction are out of specification or unless any surrogate has less than 10 percent recovery.
8. In the special case of blank analysis with surrogates out of specification, the reviewer must give special consideration to the validity of associated sample data. The basic concern is whether the blank problems represent an isolated problem with the blank alone, or whether there is a fundamental problem with the analytical process. For example, if the samples in the batch show acceptable surrogate recoveries, the reviewer may determine the blank problem to be an isolated occurrence for which no qualification of the data is required.
9. Surrogates may be reported as "diluted out" (D); if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram and quantitation report may be necessary to determine that surrogates are truly "diluted out."

Level D:

Verify that the surrogate percent recovery was calculated and reported correctly using the following equation. Recalculate all surrogate recoveries for one sample per matrix:

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form II (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

Matrix Spike/Matrix Spike Duplicate (MS/MSD) data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

The data reviewer should first try to determine the extent to which the results of the MS/MSD affect the associated data. This determination should be made with regard to the MS/MSD sample itself, as well as specific compounds for all samples associated with the MS/MSD.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

Note: If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

Level C and Level D:

The laboratory must spike and analyze an MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and relative percent difference (RPD) for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as “J.”
6. If the RPDs between MS and MSD results are greater than 20 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than two times the spike concentration or diluted by more than a factor of two should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more percent recoveries (%Rs) and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added
SR = sample result
SSR = spiked sample result
SDR = spiked duplicate result
ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are equipment blanks, field blanks, field duplicates, and field triplicates.

4.8.1 Equipment Blanks and Field Blanks

Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If semivolatile organic compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group (SDG).

2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to microgram per liter from microgram per kilogram (µg/kg) to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

1. Verify all target compound and TIC detects found in the equipment blanks and field blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and verify the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or the tentative identity is in error, request for a corrected Form I (or equivalent) for the equipment blank or field blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.8.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

1. Verify all target compound and TIC detects found in the field duplicates and/or field triplicates against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or the tentative identity is in error, request for a corrected Form I (or equivalent) for the sample or field duplicate from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.9 INTERNAL STANDARDS PERFORMANCE

Internal standards performance criteria ensure that GC/MS sensitivity and response are stable during every analytical run.

Level C and Level D:

1. If an internal standards area count for a sample is outside −50 percent or +100 percent of the area the initial calibration midpoint standard:
2. Positive results for compounds quantitated using an internal standards area count greater than 100 percent should be qualified as estimated “J.” Nondetected compounds should not be qualified.
3. Compounds quantitated using an internal standards area count less than 50 percent should be qualified as estimated “J” for detects and estimated “UJ” for nondetects.
4. If extremely low area counts are reported (less than 20 percent of the area for associated standards), detected compounds should be qualified as estimated “J” and nondetected target compounds should then be qualified as unusable “R.”
5. If an internal standards retention time varies by more than 10 seconds from the retention time of the initial calibration midpoint standard, the nondetected target compounds should be qualified as unusable “R” for Level C validation. A Level D validation examination of the raw data should be recommended to the CTO Manager. The chromatographic profile for that sample must be examined to determine if any false positives or negatives exist. For shifts of a large magnitude, the reviewer may consider partial or total rejection of the data for that sample fraction. Positive results should be qualified as “NJ” if the mass spectral criteria are met.

Level D:

Verify the internal standard areas reported on Form VIII (or equivalent) from the raw data for at least one sample per SDG, and verify internal standard areas for samples that were qualified due to out-of-control internal standard areas. If errors are discovered between the raw data and the Form VIII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.10 TARGET COMPOUND IDENTIFICATION

The objective of the criteria for GC/MS qualitative analysis is to minimize the number of erroneous identifications of target compounds. An erroneous identification can either be false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The identification criteria can be applied more easily in detecting false positives than false negatives. More information is available for false positives because of the requirement for submittal of data supporting positive identifications. However, negatives, or nondetected compounds, represent an absence of data and are, therefore, more difficult to assess. One example of detecting false negatives is the not reporting of a target compound that is reported as a TIC.

Level C:

Target compound identification is not evaluated for Level C validation because it requires the interpretation of mass spectral raw data.

Level D:

The following criteria should be followed when evaluating raw data.

1. The relative retention times (RRTs) must be within ±0.06 RRT units of the standard RRT.
2. Mass spectra of the sample compound and a current laboratory-generated standard (i.e., the mass spectrum from the associated calibration standard) must match according to the following criteria:
3. All ions present in the standard mass spectrum at a relative intensity greater than 10 percent must be present in the sample spectrum.
4. The relative intensities of these ions must agree within ± 20 percent between the standard and sample spectra. (Example: For an ion with an abundance of 50 percent in the standard spectrum, the corresponding sample ion abundance must be between 30 percent and 70 percent.)
5. Ions present at greater than 10 percent in the sample mass spectrum, but not present in the standard spectrum, must be considered and accounted for.
6. The application of qualitative criteria for GC/MS analysis of target compounds requires professional judgment. It is up to the reviewer's discretion to obtain additional information from the laboratory and CTO Manager. If it is determined that incorrect identifications were made, all such data should be qualified as not detected "U" or unusable "R."
7. Professional judgment must be used to qualify the data if it is determined that cross-contamination has occurred. Any changes made to the reported compounds or concerns regarding target compound identifications should be clearly indicated in the data validation report.

4.11 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C and Level D:

1. Verify that the reporting limits for nondetects are equal to the LOD. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD/LOQ verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable "R."
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions (including clean-up) and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. Verify that LOQs/LODs for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If not, qualify the detected compound that required dilution as "J" and document the event in the data validation report.

Level D:

The compound quantitation must be evaluated for all detects by evaluating the raw data. Compound concentrations must be calculated based on the internal standards associated with that compound, as listed in the following equation. Quantitation must be based on the quantitation ion (m/z) specified in the method or project planning document for both the internal standards and target compounds. The compound quantitation must be based on the RRF from the appropriate initial calibration standard.

Water

$$\mu g/L = \frac{A_x \times I_s \times D_f \times V_t}{A_{is} \times ARRF \times V_o \times V_i}$$

Where:

A_x = area of characteristic ion (extracted ion current profile) for compound being measured

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

I_s = amount of internal standard added (nanograms)

ARRF = average relative response factor for compound being measured

V_o = volume of water extracted (milliliter)

D_f = dilution factor

V_t = volume of extract injected (microliter [µL])

V_i = volume of concentrated extract (µL)

Soil/Sediment

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s \times D_f \times V_t \times 2.0_t}{A_{is} \times ARRF \times Ws \times D \times V_i}$$

Where:

A_x, I_s, RRF, A_{is}, V_i, V_t are as given for water, above.

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

W_s = Weight of sample extracted, in grams (g)

The factor of 2.0 in the numerator is used to account for the amount of extract that is not recovered from gel permeation chromatography clean up.

If discrepancies are discovered in the quantitation, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample analyzed by Full Scan, the laboratory may conduct a mass spectral search of the spectral library and report the possible identity for up to 30 largest semivolatile fraction peaks which are not system monitoring compounds (surrogates), internal standards, or target compounds, but which have area or height greater than 10 percent of the area or height of the nearest internal standard. TIC results are reported for each sample on the Organic Analyses Data Sheet (Form I SV-TIC [or equivalent]). TICs are not reported for SIM analysis.

Level C and Level D:

1. All TIC results should be qualified "NJ," tentatively identified with approximated concentrations.
2. The reviewer should be aware of common laboratory artifacts and their sources such as siloxane compounds, which indicate capillary column degradation, and carbon dioxide, which indicates a possible air leak in the system. These may be qualified as unusable "R."
3. If a target compound is identified as a TIC by non-target library search procedures, the reviewer should request that the laboratory recalculate the result using the proper quantitation ion.
4. TIC results that are not above the 10× level in the blank should be qualified as unusable, "R." (Dilutions and sample size must be taken into account when comparing the amounts present in blanks and samples.)

5. The reviewer may elect to report all similar compounds as a total (e.g., all alkanes may be summarized and reported as total hydrocarbons).

Level D:

1. Check each TIC for each sample using the following criteria.
2. Major ions (greater than 10 percent relative intensity) in the reference spectrum should be present in the sample spectrum.
3. The relative intensities of the major ions should agree within ±20 percent between the sample and the reference spectra.
4. Molecular ions present in the reference spectrum should be present in the sample spectrum.
5. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination, interference, or co-elution of additional TIC or target compounds.
6. When the above criteria are not met, but in the technical judgment of the data reviewer or mass spectral interpretation specialist, the identification is correct, the data validator may report the identification.
7. Since TIC library searches often yield several candidate compounds having a close matching score, all reasonable choices must be considered. The reviewer may use judgment to change the reported tentative identity.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation.*

7. Attachments

None.

Level C and Level D Data Validation for HRGC/HRMS Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by SW-846 8290

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of polychlorinated dibenzodioxin (PCDD) and polychlorinated dibenzofurans (PCDF) data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all high resolution gas chromatograph/high resolution mass spectrometry (HRGC/HRMS) PCDD and PCDF data.

4. Procedure

This procedure addresses the validation of PCDD and PCDF data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 8290 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form and Internal Standard Summary Form

- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form
- Form IV: Method Blank Summary Form
- Form V: Instrument Performance Check Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Samples are to be shipped in coolers that are maintained at above freezing to 6 degrees Celsius (°C). If the temperature exceeds 6°C, note this in the data validation report and no data qualification shall be required. PCDDs and PCDFs are environmentally stable and are not expected to degrade significantly during transit or storage. If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.
2. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all PCDD and PCDF analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for PCDDs and PCDFs but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

There is no holding time for PCDDs and PCDFs per Chapter 2 of EPA SW-846 (EPA 2007). If the recommended holding time criteria below are not met, data will not be qualified.

Water samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 30 days of collection and analyzed within 45 days of extraction.

Soil samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 30 days of collection and analyzed within 45 days of extraction.

4.2 HRGC/HRMS INSTRUMENT PERFORMANCE CHECK

Level C and Level D:

HRGC/HRMS instrument performance checks are performed to ensure mass resolution, identification, and to some degree, sensitivity. These criteria are not sample specific. Conformance is determined using standard materials; therefore, these criteria should be met in all circumstances.

The analysis of the instrument performance check, Perfluorokerosene (PFK), must be performed at the beginning of each 12-hour period during which samples or standards are analyzed.

Level C and Level D:

1. Verify that the mass spectrometer has been tuned to a resolution of ≥10,000. If the resolution is <10,000 or is not demonstrated, all of the associated data will be qualified as unusable "R."
2. Check that retention time windows for all homologues were established with the analysis of a Window Defining Mix (WDM). If the WDM was not analyzed but the calibration standards met specifications, flag the total homologue results as estimated "J" or "UJ."

3. Check that chromatographic resolution between 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and peaks representing any other unlabeled TCDD isomer was less than or equal to 25 percent on the DB-5 column (or equivalent). If not within criteria, flag detects for 2,3,7,8-TCDD as estimated “J” and nondetects as estimated “UJ” in all the associated samples.
4. Check that chromatographic resolution between 2,3,7,8-tetrachlorodibenzo-p-dibenzofuran (TCDF) and the 2,3,4,7-TCDF peak was less than or equal to 25 percent on the DB-225 column (or equivalent). If not within criteria, flag detects for 2,3,7,8-TCDF as estimated “J” and nondetects as estimated “UJ” in all the associated samples.
5. Verify that a performance check sample was analyzed daily. Verify the laboratory evaluated peak resolution and peak shape.
6. Check that the exact mass of 380.9760 PFK was verified.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the PCDD and PCDF target compound list.

4.3.1 Initial Calibration

Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing an acceptable calibration curve.

Level C and Level D:

1. Check Form VI (or equivalent) and evaluate the percent relative standard deviation (%RSD) for all unlabeled and labeled compounds. If any unlabeled compound has a %RSD of greater than 20 percent or any labeled compound has a %RSD greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in the associated samples.
2. Check that ion abundance ratios for all PCDDs and PCDFs met method criteria. If not within criteria, flag results for the affected compounds as unusable “R” in the associated samples. A more in-depth review to minimize qualification of data may be accomplished by considering the following:
    a. If the ion abundance ratio is outside the limits for an analyte in the CS1 solution, then the low-end results for that analyte (below the CS2 concentration) are flagged as non-detect “U” at the CS2 concentration or unusable “R” in the associated samples.
    b. If the ion abundance ratio is outside the limits for an analyte in the CS3–CS5 solutions, flag the analyte results as unusable “R” in the associated samples.
3. Check that the retention times (RTs) of the isomers are within the appropriate RT windows established by the WDM analysis. In addition, the absolute RT of the internal standard 13C12-1,2,3,4-TCDD must exceed 25 minutes on the DB-5 column (or equivalent) and 15 minutes on the DB-225 column (or equivalent). If not within criteria, flag detected results

for the affected compounds as estimated "J" and nondetects as unusable "R" in the associated samples.

Level D:

1. Verify the files reported on Form VI (or equivalent) against the quantitation reports and selected ion current profiles (SICPs). If the files do not match, the relative response factors (RRFs) reported are likely to be from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the average RRFs and %RSDs reported on Form VI (or equivalent) for five PCDDs and/or PCDFs from the raw data, (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.
3. Verify that the instrument sensitivity criteria are met in all SICPs. For all calibration solutions, including CS1, the signal-to-noise (S/N) ratio must be ≥10.0 for all PCDD/PCDF peaks, including the labeled versions of native compounds and the internal standards. If not within criteria, flag nondetects as unusable "R" in all the associated samples.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any unlabeled compound has a percent difference (%D) of greater than 20 percent or any labeled compound has a %D greater than 30 percent, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in all samples associated with the initial calibration.
3. Check that ion abundance ratios for all PCDDs and PCDFs met method criteria. If not within criteria, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in the associated samples.

Level D:

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

The continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

Level C and Level D:

1. Verify the continuing calibration was analyzed at the beginning and end of each 12-hour period.
2. For the beginning continuing calibration, check Form VII (or equivalent) and evaluate the %D for all unlabeled and labeled compounds. If any unlabeled compound has a %D of greater than 20 percent or any labeled compound has a %D greater than 30 percent, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in the associated samples.
3. For the ending continuing calibration, if any unlabeled compound has a %D greater than 25 percent or any labeled compound has a %D greater than 35 percent, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in the associated samples. Verify that the average RRF of the ending and beginning continuing calibrations was used to quantitate the samples instead of the average RRF from the initial calibration.
4. Check that ion abundance ratios for all PCDDs and PCDFs met method criteria. If not within criteria, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in the associated samples.
5. Check that the RTs of the isomers are within the appropriate RT windows established by the WDM analysis. Check that the absolute RT of the internal standard $^{13}C_{12}$-1,2,3,4-TCDD exceeded 25 minutes on the DB-5 column (or equivalent) and 15 minutes on the DB-225 column (or equivalent). In addition, the absolute RT of the internal standards must be within 15 second of the RTs obtained during the initial calibration. If not within criteria, qualify data using professional judgment.

Level D:

1. Verify the files reported on Form VII (or equivalent) against the quantitation reports and SICPs. If the files do not match, the RRFs reported are likely to be from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the average RRFs and %Ds reported on Form VII (or equivalent) for five PCDDs and/or PCDFs from the raw data, (preferably compounds which were identified in the samples). If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.
3. Verify that the instrument sensitivity criteria are met in all SICPs. The S/N ratio must be ≥10.0 for all PCDD/PCDF peaks, including the labeled versions of native compounds and the internal standards. If not within criteria, flag detects as estimated "J" and nondetects as unusable "R" in all the associated samples.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias in the data, or if the problem is an isolated occurrence not affecting other data. Results may not be corrected by subtracting any blank values.

Level C and Level D:

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable “R.” Nondetects do not require qualification.
2. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the 5× criteria discussed below, such that a comparison of the total amount of contamination is actually made.
3. If a compound is found in the blank, but not in the associated sample, no action is taken.
4. Compounds that are detected in both the sample and the associated blank shall be qualified when the sample concentration is less than or equal to 5 times the blank concentration (5× rule). The applicable review qualifier(s) are summarized in Table II-D-1.

Table II-D-1: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
>EDL and less than appropriate 5× rule	Leave as reported	U
Greater than appropriate 5× rule	Leave as reported	None

EDL estimated detection limit

5. If gross contamination exists in the blanks (i.e., saturated peaks by HRGC/HRMS), all compounds affected shall be flagged as unusable “R” due to interference in all samples affected and this shall be noted in the data validation comments.
6. If target compounds are found at low levels in the blank(s), it may be indicative of a problem at the laboratory and shall be noted in the data validation report.
7. Additionally, there may be instances where little or no contamination was present in the associated blanks, but qualification of the sample was deemed necessary. For example, an analyte was detected in the method blank but did not meet the ion ratio requirement; however, in the associated sample, the analyte was detected with an acceptable ratio and the concentration is less than 5× the blank concentration. The sample value shall be reported as a nondetect and the reason shall be documented in the data validation report.
8. If gross contamination exists in the blanks (i.e., saturated peaks), all compounds affected shall be flagged as unusable “R” due to interference in all samples affected and this shall be noted in the data validation comments.

Level D:

1. Verify all target compounds found in the method blanks against the raw data.
2. Verify that the target compound detects are valid, as defined in Section 4.9. If reported detects are not valid, request for a corrected Form I (or equivalent) for the method blank from the laboratory.

3. Verify detected concentrations of target compounds from the raw data, as defined in Section 4.10. After the validity of the target compounds is verified, validate the corresponding data using the criteria outlined above.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are below 10 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 10 percent), spiked compounds that showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds that showed high recovery in all associated samples shall be flagged as estimated “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent difference (RPD) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one or more spike recoveries per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

The data reviewer should first try to determine the extent to which the results of the MS/MSD affect the associated data. This determination should be made with regard to the MS/MSD sample itself, as well as specific compounds for all samples associated with the MS/MSD.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

Note: If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

Level C and Level D:

The laboratory must spike and analyze an MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and RPD for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable "R" for nondetects and estimated "J" for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated "UJ" or "J."
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as estimated "J."

6. If the RPDs between MS and MSD results are greater than 20 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated "J."
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than two times the spike concentration or diluted by more than a factor of two should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added
SR = sample result
SSR = spiked sample result
SDR = spiked duplicate result
ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.7 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are equipment blanks, field blanks, field duplicates, and field triplicates.

4.7.1 Equipment Blanks and Field Blanks

Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If PCDDs and PCDFs are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the 5× rule outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group (SDG).
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to picograms per liter (pg/L) from picograms per gram (pg/g) to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

1. Verify all target compounds found in the equipment blanks and field blanks against the raw data.
2. Verify that the target compound detects are valid, as defined in Section 4.9. If reported detects are not valid, request for a corrected Form I (or equivalent) for the equipment blank or field blank from the laboratory.
3. Verify detected concentrations of target compounds from the raw data, as defined in Section 4.10. After the validity of the target compounds is verified, validate the corresponding data using the criteria outlined above.

4.7.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.

2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

1. Verify all target compound detects found in the field duplicates and/or field triplicates against the raw data.
2. Verify that the target compound detects are valid, as defined in Section 4.9. If reported detects are not valid, request for a corrected Form I (or equivalent) from the laboratory.
3. Verify detected concentrations of target compounds from the raw data, as defined in Section 4.10. After the validity of the target compounds is verified, validate the corresponding data using the criteria outlined above.

4.8 INTERNAL STANDARDS PERFORMANCE

Internal standards performance criteria ensure that HRGC/HRMS sensitivity and response is stable during every run. If any internal standard is out of specification, then there should be a re-analysis of the sample with the internal standard results outside the criteria.

Level C and Level D:

1. If an internal standards recovery is less than 40 percent but greater than or equal to 10 percent or if an internal standards recovery is greater than 135 percent, qualify all results for compounds quantitated using that internal standards as estimated “J” or “UJ.”
2. If an internal standards recovery is less 10 percent, qualify detects for compounds quantitated using that internal standards as estimated “J” and non-detects as unusable “R.”
3. If the internal standards ion abundance ratio did not meet method criteria but the associated calibration standard was acceptable, quantitative results may have been influenced by interference. Qualify all results for compounds quantitated using that internal standards as estimated “J” or “UJ.”
4. If the internal standards ion abundance ratio did not meet method criteria and the associated calibration standard was not compliant, qualify detect results for compounds quantitated using that internal standards as estimated “J” and non-detects as unusable “R.”
5. If internal standards recovery is considerably greater than 135 percent, a special note should be documented in the data validation summary.
6. The 37Cl-labeled clean-up standard is used to monitor the efficiency of the clean-up; it is added to the sample extracts after extraction and before any clean-up steps. If the recovery is less than the QC limits, qualify all results associated with the clean-up standard as estimated “J” or “UJ.”

Level D:

1. Verify the S/N ratio for internal standard peaks was ≥10. If criteria were not met and the internal standards recovery is less than 10 percent, qualify all results for compounds quantitated using that internal standards as unusable "R."
2. Verify the reported internal standard recoveries against the raw data for at least one sample per SDG, and verify internal standard recoveries for samples that were qualified due to out-of-control internal standard recoveries. If errors are discovered between the raw data and the reported recoveries, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.9 TARGET COMPOUND IDENTIFICATION

The objective of the criteria for HRGC/HRMS qualitative analysis is to minimize the number of erroneous identifications of target compounds. An erroneous identification can either be false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The identification criteria can be applied more easily in detecting false positives than false negatives. More information is available for false positives because of the requirement for submittal of data supporting positive identifications. However, negatives, or nondetected compounds, represent an absence of data and are, therefore, more difficult to assess.

Level C:

1. If the laboratory identified results as estimated maximum possible concentration, flag detects for the affected compounds as estimated "J" in the associated samples.

Target Compound Identification is not evaluated for Level C validation because it requires the interpretation of SICPs.

Level D:

The following criteria should be followed when evaluating raw data.

1. Check to ensure that 2,3,7,8 substituted congeners with associated labeled standard retention times of the two quantitation peaks are within -1 to 3 seconds of the RT of the labeled standard. If not within criteria, flag detects for the affected compounds as unusable "R" in the associated samples.
2. Check to ensure that 2,3,7,8 substituted congeners without associated labeled standards relative retention times (RRTs) of the two quantitation peaks are within 0.005 time units of the standard RRT (routine calibration). If not within criteria, flag detects for the affected compounds as unusable "R" in the associated samples.
3. Check to ensure that non-2,3,7,8 substituted congeners retention times of the two quantitation peaks are within the RT established in the performance check solution. If not within criteria, flag detects for the affected compounds as unusable "R" in the associated samples.

4. Check the SICPs for the criteria listed below. If not within criteria or the SICP is missing and cannot be obtained from the laboratory, flag detects for the affected compounds as unusable “R” in the associated samples.
    a. The SICP must contain all characteristic ions for the homologue. This includes the quantitation ion, confirmation ions, and M-COCL ions.

    b. The ion current responses for the two quantitation ions for each analyte must maximize simultaneously within the same 2 seconds (includes labeled standards).

    c. The relative intensity of the isotopic ions must be within the molecular ion cluster abundance criteria established for the calibration.

5. Verify the S/N ratio for each target compound was ≥2.5 and that the detector was not saturated. If not within criteria, flag detects for the affected compounds as estimated “J” in the associated samples.
6. Check to ensure that there was no signal (S/N ≥2.5) detected in the polychlorinated diphenyl ether (PCDPE) channel for PCDF identification. All sample results with co-eluting PCDPE interference will be qualified as estimated “J.”
7. Check that ion abundance ratios for all PCDDs and PCDFs met method criteria. If the laboratory identified the result as estimated maximum possible concentration, verify ion abundance ratios did not meet method criteria, and check that the all qualitative identification criteria (Level D items 1 through 6) were met. Flag detects for the affected compounds as estimated “J” in the associated samples. If not all qualitative identification criteria were met, employ professional judgment.
8. Check to ensure an acceptable lock mass was recorded and monitored.
9. The application of qualitative criteria for HRGC/HRMS analysis of target compounds requires professional judgment. It is up to the reviewer's discretion to obtain additional information from the laboratory and CTO Manager. If it is determined that incorrect identifications were made, all such data should be flagged as not detected “U” or unusable “R.”
10. Professional judgment must be used to qualify the data if it is determined that cross-contamination has occurred. Any changes made to the reported compounds or concerns regarding target compound identifications should be clearly indicated in the data validation report.

4.10 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., limit of quantitation [LOQ], estimated detection limit [EDL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C and Level D:

1. Second column confirmation is required for any sample in which 2,3,7,8-TCDF is detected or reported as an estimated maximum possible concentration at or above the LOQ. If not

performed, note this in the data validation report. The confirmatory analysis is not required when the GC column that was used meets isomer specificity requirements for both 2,3,7,8-TCDD and 2,3,7,8-TCDF.

2. Verify that the reporting limits for nondetects are equal to the EDLs. EDL is the concentration of a given analyte required to produce a signal with a peak height of at least 2.5 times the background signal level.
3. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest EDLs are used unless a QC criterion has been exceeded. In this case, the higher EDLs from the diluted analysis are used. The least technically sound data will be flagged “R” with a qualification code “D.”
4. Verify that EDLs for soils and sediments were calculated based on dry weight. If the EDLs were reported based on wet weight, the percent moisture must be factored in and the EDLs must be adjusted accordingly.
5. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If not, qualify the detected compound that required dilution as estimated “J” and document the event in the data validation report.
6. Verify that qualifers are added to total dioxin /furans if qualifiers are added to the associated individual dioxin/furan congeners.

Level D:

The compound quantitation must be evaluated for all detects by evaluating the raw data. Compound concentrations must be calculated based on the internal standards associated with that compound, as listed in the following equation. Quantitation must be based on the quantitation ion (m/z) specified in the analytical method for both the internal standards and target compounds. The compound quantitation must be based on the RRF from the appropriate initial calibration standard.

Water

$$\text{pg/L} = \frac{A_x \times I_s \times D_f}{A_{is} \times \text{ARRF} \times V_o}$$

Where:

A_x = integrated current for the characteristic ions for compound being measured

A_{is} = integrated current for the characteristic ions of the internal standard

D_f = dilution factor

I_s = amount of internal standard added (pg/L)

ARRF = average relative response factor for compound being measured

V_o = sample volume (L)

Soil/Sediment

$$\text{Concentration } pg/g \text{ (Dry weight basis)} = \frac{A_x \times I_s \times D_f}{A_{is} \times ARRF \times W_s \times D}$$

Where:

A_x, I_s, D_f, ARRF, A_{is} are as given for water, above.

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

$W_{\}\}\}}$ = Weight of sample extracted, in grams (g)

If discrepancies are discovered in the quantitation, document any corrections in the data validation report.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped “NAVFAC PACIFIC VALIDATED.” Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted “Level D.”

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of total petroleum hydrocarbons (TPH) data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography (GC) TPH data.

4. Procedure

This procedure addresses the validation of TPH data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 8015 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: TPH Analytical Sequence Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

TPH as Gasoline

1. Water samples must be preserved with hydrochloric acid at or below a pH of 2 and refrigerated at above freezing to 6 degrees Celsius (°C).
2. Soil samples collected in volatile organic analysis (VOA) vials or coring devices must be refrigerated at above freezing to 6°C. If the samples are to be analyzed after the 48-hour holding time, the laboratory must preserve the samples with sodium bisulfate or methanol or freeze upon receipt in accordance with EPA SW-846 Method 5035 (EPA 2007).
3. If the analyzed aqueous VOA vial contains air bubbles or headspace, is cracked, or has a cracked cap, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” The sample data may be qualified as unusable “R” if the container damage is extensive or improper sealing is identified.
4. VOA vials are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C, but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature of receipt is greater than or equal to 15°C, positive values shall be flagged as estimated “J” and nondetects as unusable “R.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.

TPH as Extractables

1. Samples are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C but is less than or equal to 10°C, note this in the data validation

report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated "J" and nondetects as estimated "UJ." If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.

2. Water samples shall not be preserved; they shall only be kept cool. If the water samples were inappropriately preserved with acid, the samples should not be analyzed. Analysis of an inappropriately preserved sample by the laboratory may require that all results be reported as unusable "R."
3. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all TPH analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I (or equivalent) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for TPH but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and Form I (or equivalent) shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times for TPH are measured from the time of collection (as shown on the COC) to the time of sample extraction and from the time of sample extraction to the time of sample analysis (as shown on the Form I [or equivalent]). Samples and extracts must be stored and refrigerated at above freezing to 6°C until the time of analysis.

TPH as Gasoline

1. Water samples must be preserved with hydrochloric acid and refrigerated at above freezing to 6°C. Preserved water samples shall be analyzed within 14 days from the collection date. If there is no indication of chemical preservation, assume samples are unpreserved. For unpreserved water samples, the holding time is 7 days from date collected.
2. Soil samples collected in VOA vials or coring devices that are unpreserved must be refrigerated at above freezing to 6°C and analyzed within 48 hours from the collection date. Soil samples that are preserved with sodium bisulfate or methanol, or frozen upon laboratory receipt shall be analyzed within 14 days from the collection date.

TPH as Extractables

Water samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 7 days of collection and analyzed within 40 days of extraction.

Soil samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 14 days of collection and analyzed within 40 days of extraction.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a non-preserved water sample has an extraction holding time of more than 14 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

4.2 GC INSTRUMENT PERFORMANCE

Level C:

Instrument performance is not evaluated for Level C validation.

Level D:

Evaluate the blank, standard, laboratory control sample, and sample chromatograms to ascertain the performance of the chromatographic system. Professional judgment should be used to qualify the data when unacceptable chromatographic conditions preclude proper quantitation or identification of TPH.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that an instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that an instrument is capable of acceptable performance at the beginning of a sequence, and continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

Level C and Level D:

1. The proper analytical sequence must be followed to ensure proper quantitation and identification of all target compounds. For the quantitation analysis, standards containing all target compounds, (specific hydrocarbon products or n-alkanes) must be analyzed in the initial calibration at the beginning of the sequence. If n-alkane ranges rather than specific hydrocarbon products are being reported, n-alkane standards must be run in the initial calibration and should be analyzed periodically to ensure proper identification of the n-alkane range reported. An initial calibration verification standard must be analyzed following each initial calibration. The mid-level standard of the initial calibration must be analyzed after every 10 samples as the continuing calibration and at the end of the sequence to ensure system performance has not degraded. If the proper sequence has not been analyzed, use professional judgment to assess the reliability of the data.
2. The laboratory should report retention time window data for each compound and each column used to analyze the samples. The retention time windows are used for qualitative identification. The laboratory should also report quantitation ranges used for integration when analyzing samples. If the compounds in the continuing calibration standard do not fall within the retention time windows established in the initial calibration, the associated sample results should be carefully evaluated, especially the retention time of the surrogate spike compound. All samples injected after the last in-control standard are potentially affected.

4.3.1 Initial Calibration

Level C and Level D:

For the initial calibration (at least five-points), the relative standard deviation (RSD) of the calibration factor (CF) for each target compound must be less than or equal to 20 percent. Verify the RSDs from the initial calibration summary forms. Alternatively, a linear curve may be used with a coefficient of determination; r^2 equal to or greater than 0.990. A second order calibration curve may also be used after evaluating the laboratory's acceptance criteria. If the initial calibration criteria are not met, flag all associated quantitative results as estimated “J” for detects and estimated “UJ” for nondetects.

Level D:

Verify the percent RSDs, r^2, or laboratory established measure of linearity for the initial calibration from the raw data. Verify the CF for each target compound from the raw data on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in all samples associated with the initial calibration.

Level D:

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

Level C and Level D:

Verify the %D from the continuing calibration summary forms. For the continuing calibration, the %D between the CF from the continuing calibration and the average CF from the initial calibration must be less than 20 percent. Alternatively, if a linear (first-order) calibration curve is utilized in the initial calibration, the %D of the calculated amount and the true amount for each compound must be less than or equal to 20 percent. If the continuing calibration criteria are not met, qualify all associated results as estimated "J" for detects and "UJ" for nondetects.

Level D:

Verify the %Ds from the raw data.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias associated with the data, or if the problem is an isolated occurrence not affecting other data. No contaminants should be present in the method blank(s). The method blank should be analyzed on each GC system used to analyze site samples.

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable "R." Nondetects do not require qualification.
2. If the method blank was not analyzed on a GC used to analyze site samples, note the deficiency in the data validation report. Professional judgment shall be used for subsequent qualification of the data.
3. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.

4. If a compound is found in the blank, but not in the associated sample, no action is taken.
5. Any compound detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Care should be taken to factor in the percent moisture when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table II-H-1.

Table II-H-1: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ and blank result is <, > or = LOQ	Leave as reported	U
≥LOQ, blank result is <LOQ	Leave as reported	None
≥LOQ, blank result is >LOQ and sample result <blank result	Leave as reported	Use professional judgment
≥LOQ, blank result is >LOQ and sample result ≥blank result	Leave as reported	Use professional judgment
≥LOQ and blank result is = LOQ	Leave as reported	Use professional judgment

6. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
7. Instances of contamination can be attributable to the dilution process. These occurrences are difficult to determine; however, the reviewers should qualify the sample data as nondetects, “U,” when the reviewer determines the contamination to be from a source other than the sample.
8. In the event of gross contamination (i.e., saturated peaks) in the blanks, the associated samples must be evaluated for gross contamination. If gross contamination exists in the samples, the affected compounds should be qualified as unusable, “R.”

Level D:

1. Verify from the preparation log that the information recorded on Form IV (or equivalent) is correct.
2. Review the results of all blank raw data and Form I (or equivalent) to ensure that there were no false negatives or false positives.
3. Verify all target compound detects found in the method blanks against the raw data. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure. After the validity of the target compounds are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable "R" for nondetects and estimated "J" for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated "UJ" or "J."
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated "J."
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated "UJ" or "J."

Level D:

To verify that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SURROGATE RECOVERY

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects because of factors such as interferences and high concentrations of compounds. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. The following procedures shall be followed:

Level C and Level D:

Sample and blank surrogate recoveries for TPH must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).

1. If recovery is below the QC limits for any of the surrogates, but above or equal to 10 percent, flag associated positive results as estimated “J” and nondetects as “UJ.”
2. If any surrogate recovery is less than 10 percent, flag all nondetects as unusable “R” and detects as estimated “J.” No qualification is applied if surrogates are diluted beyond detection but note in the data validation report that surrogate evaluation could not be performed due to the high dilution factor.
3. If any surrogate recovery is above the upper QC limit, flag associated positive results as estimated “J.” No qualification of nondetects is necessary in the case of high recoveries.
4. Surrogates may be reported as “diluted out” (D); if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram may be necessary to determine that surrogates are truly “diluted out.”

Level D:

The reported surrogate recoveries on Form II should be verified from the raw data for a representative number of samples.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

The data reviewer should first try to determine the extent to which the results of the MS/MSD affect the associated data. This determination should be made with regard to the MS/MSD sample itself, as well as specific compounds for all samples associated with the MS/MSD.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the

MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

Note: If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

Level C and Level D:

The laboratory must spike and analyze a MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and RPD for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as “J.”
6. If the RPDs between MS and MSD results are greater than 30 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than 2 times the spike concentration and or diluted by more than a factor of 2 should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$\text{RPD} = \frac{\text{ABS}|\text{SSR} - \text{SDR}|}{(\text{SSR} + \text{SDR})/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are equipment blanks, field blanks, field duplicates, and field triplicates.

4.8.1 Equipment Blanks and Field Blanks

Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If TPH compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample deliver group.
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to micrograms per liter from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

Compound identification and quantification of field blank and equipment blank samples must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.8.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Before comparison of duplicates and/or triplicates, the compound identification and quantification must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.9 TARGET COMPOUND IDENTIFICATION

Qualitative criteria for compound identification have been established to minimize the number of erroneous identifications of compounds. An erroneous identification can be either a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

Level C:

Compound identification is not verified for Level C validation.

Level D:

1. Review Form I or equivalent. Check for errors.

2. Verify that the retention times of sample compounds reported on the Form X or equivalent fall within the calculated retention time windows.
3. Evaluate all sample chromatograms to ensure that the TPH results were properly identified. Presence of unknown single peaks may result in false positives or false negatives. The reviewer should use professional judgment in evaluating the effect of interference.

4.10 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C:

Specific compound quantitation is not verified for Level C validation.

Level C and Level D:

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD/LOQ verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable “R.”
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged “R” with a qualification code “D.”
3. Verify that reported limits for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. If a sample requiring a dilution analysis due to a target compound detect exceeding the calibration linear range was not re-analyzed at a dilution, the compound exceeding calibration range shall be qualified as estimated “J.”
5. If the laboratory re-analyzed a sample and submitted both sample results, the reviewer must determine which of the two analyses has better data quality. Only one analysis should be reported and the other is rejected.

Level D:

1. Compound quantification should be verified by recalculation from the raw data for a representative number of samples.
2. Verify from the standard chromatograms that the instrument sensitivity is adequate to support the LODs. Poor sensitivity may result in elevated LODs.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for Metals by SW-846 6000/7000

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of metals data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command, Pacific (NAVFAC Pacific) and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Cursory validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all metals data.

4. Procedure

This procedure addresses the validation of metals data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 6000/7000 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Initial and Continuing Calibration Verification Form
- Form III: Blanks Form
- Form IV: ICP Interference Check Sample Form

- Form VA: Spike Sample Recovery Form
- Form VB: Post Digest Spike Sample Recovery Form
- Form VI: Duplicates Form
- Form VII: Laboratory Control Sample Form
- Form VIII: Standard Addition Results Form
- Form IX: ICP Serial Dilutions Form
- Form X: Instrument Detection Limits Form
- Form XI: ICP Inter-element Correction Factors Form
- Form XII: ICP Linear Ranges Form
- Form XIII: Preparation Log Form
- Form XIV: Analysis Run Log Form
- Form XV: ICP-MS Internal Standards

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Metals and Mercury - Samples must be preserved with nitric acid to a pH less than 2. If analyses for dissolved metals are requested, samples should be filtered before adding preservatives. If total metals are requested, unfiltered samples should be used. Document these occurrences in the data validation report.
2. Soil samples must be refrigerated at above freezing to 6 degrees Celsius (˚C).
3. Organic Lead samples should be collected without headspace and stored at above freezing to 6°C.
4. Based upon professional judgment, analysis of an inappropriately preserved sample by the laboratory may result in qualification of the sample results as estimated “J” or “UJ.” In extreme cases of a destructive preservative, the sample data may be qualified as unusable, “R.”
5. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

6. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all metal analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Verify collect dates, sampling times, and time zones. This is critical to evaluating parameters with short holding times.
2. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for metals but were not requested should also be noted.
3. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
4. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
5. Internal chain of custody is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
7. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times are determined from the time of sample collection to the time of sample analysis. Holding times are as follows:

- Metals – 6 months for soil and water
- Mercury – 28 days for both soil and water
- Organic Lead – 14 days to extraction and 40 days from extraction to analysis for soil samples; 7 days to extraction and 40 days from extraction to analysis for water samples

If holding times are exceeded, flag all results greater than the detection limit (DL) as estimated “J” and all results less than the DL as estimated “UJ.” If holding times are grossly exceeded, the reviewer may determine that the data reported as nondetects are unusable “R.” Data will not be qualified unusable “R” unless the holding time was grossly exceeded by more than a factor of 2.

4.2 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run and of producing a linear calibration curve. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory.

4.2.1 Initial Calibration

Level C and Level D:

Instruments must be calibrated daily prior to sample analysis and each time the instrument is set up.

1. Inductively Coupled Plasma (ICP) Analysis: A blank and at least one high standard must be used in establishing the analytical curve. If more than one standard is used, r^2 must be 0.99 or greater.
2. Graphite Furnace Atomic Absorption (GFAA) Analysis: A blank and at least three standards must be used in establishing the analytical curve. Linearity is determined using linear regression analysis. The correlation coefficient, r must be 0.995 or greater.
3. Cold Vapor Atomic Absorption (CVAA), Mercury Analysis: A blank and at least five standards must be used in establishing the analytical curve. Linearity is determined using linear regression analysis. The correlation coefficient must be 0.995 or greater.

If the correlation coefficient is below 0.995, qualify all associated detects as estimated “J” and all nondetects as “UJ.” If the correlation coefficient is significantly lower than 0.995, professional judgment may be used to reject, “R,” the analytes associated with the initial calibration.

Level D:

Recalculate the correlation coefficient for all initial calibrations. Verify from the raw data that appropriate concentration and number of standards were utilized to establish analytical curves and the associated correlation coefficients.

4.2.2 Initial and Continuing Calibration Verification (ICV and CCV)

Level C and Level D:

1. Review Form II (Part I) for ICV and CCV percent recovery (%R) values.
2. Analysis results for Method 6000 ICV and CCV must fall within the control limits of 90-110 percent recovery of the true value for all analytes.
3. Analysis results for Method 7000 ICV and CCV must fall within the control limits of 90-110 percent recovery.
4. If after a failing CCV, two additional consecutive CCVs are analyzed immediately, and both additional CCVs are within the control limits, the data is acceptable. If either of the additional CCVs is not within control limits, then the associated data will need qualification. See below for the recommended qualification guidelines.

5. Because of rounding discrepancies, let the results fall within 1 percent of the acceptance windows (e.g., 89–111 percent).
6. If the ICV or CCV %R falls outside the acceptance windows, use professional judgment to qualify all associated data. The following guidelines are recommended:
    a. If the ICV or CCV %R falls outside the acceptance windows but within the ranges of 75-89 percent or 111–125 percent, qualify results greater than the DL as estimated “J.”
    b. If the ICV or CCV %R is within the range of 111–125 percent, results less than the DL are acceptable.
    c. If the ICV or CCV %R is 75–89 percent, qualify results less than the DL as nondetected and estimated “UJ.”
    d. If the ICV or CCV %R is less than 75 percent, qualify results greater than the DL as estimated “J” and results less than the MDL as unusable “R.”
    e. If the ICV or CCV percent recovery is greater than 125 percent, qualify results greater than the DL as unusable “R”; results less than the DL are acceptable.
    f. Because no raw data is evaluated at Level C, it is unnecessary to evaluate the correlation coefficient for the initial calibrations for the graphite furnace analyses.

Note: Level C data validation does not encompass reviews of the raw data; therefore, the concentration and number of standards utilized to establish analytical curves and the associated correlation coefficients are not verified. The reviewer should note in the data validation summary that this information was not reviewed.

Level D:

1. Recalculate and verify one or more of the ICV and CCV %Rs per type of analysis using the following equation for %R. Once again, due to possible rounding discrepancies, allow the results to fall within 1 percent of the acceptance windows (e.g., 89–111 percent)

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Concentration (in micrograms per liter [μg/L]) of each analyte measured in the analysis of the ICV or CCV solution.

Q_a = Concentration (in μg/L) of each analyte in the ICV or CCV source.

2. If discrepancies are discovered on any Form II, request a resubmittal from the laboratory and validate according to the criteria outlined above.

4.3 BLANKS

Method (preparation) and calibration blank analyses results are assessed to determine the existence and magnitude of laboratory contamination problems. If problems with any blank exist, all data associated with the blank must be carefully evaluated to determine whether there is a bias on the data, or if the problem is an isolated occurrence not affecting data.

4.3.1 Calibration Blanks

Level C and Level D:

1. If the blank is less than the LOQ and the samples results are greater than the DL but less than the LOQ, then qualify "U" at the result.
2. If the blank is less than the LOQ and the sample results are greater than the LOQ or nondetect, the data is acceptable.
3. If the blank is greater than the LOQ, then samples less than 5× the blank will be qualified as "U" at the concentration. Samples greater than 5× the blank are acceptable.
4. For negative blanks where the absolute value of the blank is greater than the LOQ, sample results that are less than 10x the absolute value of the negative blank qualify "J" for detect and 'UJ" for nondetect results. Results that are greater than 10× the absolute value of the negative blank are acceptable.

Ensure that units are correct when applying calibration blank qualifications. If samples are soil matrix, results must first be converted to µg/L from milligrams per kilogram to make correct comparisons.

Level D:

Verify one or more of the calibration blank results per type of analysis by comparing the Form III to the raw data. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.3.2 Method (Preparation) Blanks

Level C and Level D:

At least one method blank must be prepared with each batch of samples. If a method blank was not prepared and analyzed as required, the reviewer may qualify associated sample results less than the DL as nondetected and estimated "UJ," and sample results greater than the DL as estimated "J." Professional judgment should be utilized, however, taking into account the results of other associated blanks (e.g., initial calibration blank, continuing calibration blank).

If metals are detected in the method blanks, the procedure for the qualification of associated sample results is identical to the rules outlined in Section 4.3.1 of this procedure.

Level D:

Verify out-of-control method blanks that result in the qualification of numerous analytes against the raw data. Verify the results reported on Form III. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.4 ICP INTERFERENCE CHECK SAMPLE (ICP ICS)

The ICP ICS verifies the inter-element and background correction factors. An ICS must be run at the beginning of each sample analysis run.

Level C and Level D:

Review Form IV for the ICP ICS solution A and solution AB sample results and percent recovery values. Results for the ICP ICS solution AB analysis must fall within the control limits of ±20 percent of the true value. Aluminum (Al), calcium (Ca), iron (Fe), and magnesium (Mg) must be reported on the Form IV for solution A and solution AB to properly evaluate the ICP ICS. For samples with concentrations of Al, Ca, Fe, and Mg which are comparable to or greater than their respective levels in the ICS:

1. If the ICS AB recovery for an analyte is greater than 120 percent and the sample results are less than the DL, this data is acceptable for use.
2. If the ICS AB recovery for an analyte is greater than 120 percent and the sample results are greater than the DL, qualify the affected data as estimated “J.”
3. If the ICS AB recovery for an analyte is between 50 percent and 79 percent and the sample results are greater than the DL, qualify the affected data as estimated “J.”
4. If sample results are less than the DL and the ICS AB recovery for that analyte is within the range of 50–79 percent, the possibility of false negatives may exist. Qualify the data for these samples as nondetected and estimated “UJ.”
5. If ICS AB recovery results for an analyte are less than 50 percent, qualify the affected data as unusable “R.”
6. If the absolute value of the ICS A is greater than the limit of detection (LOD) and the sample result is greater than the DL but less than 10× the ICS A finding, qualify as estimated “J.”
7. If the absolute value of the ICS A is greater than the LOD and the sample result is greater than 10× the ICS A finding, this data is acceptable.
8. If the positive value of the ICS A is greater than the LOD and the sample results are less than the DL, this data is acceptable for use.
9. If the absolute value of the negative ICS A is greater than the LOD and the sample results are less than the DL, this data is estimated “UJ.”

Level D:

Recalculate and verify one or more ICS percent recoveries for the initial and final ICS analyses using the following equation. Verify the results reported on Form IV (or equivalent). If discrepancies are discovered, request a resubmittal from the laboratory and validate the associated data accordingly using the criteria outlined above.

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Concentration (in µg/L) of each analyte measured in the analysis of the ICS solution.

Q_a = Concentration (in µg/L) of each analyte in the ICS source.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are less than 50 percent, only the spiked analytes that showed low recovery in all associated samples shall be flagged as “R” for nondetects and “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 50 percent), spiked analytes that showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked analytes that showed high recovery in all associated samples shall be flagged as “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate (MSD) RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked analytes which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form VII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 MATRIX SPIKE/MATRIX SPIKE DUPLICATE AND MATRIX DUPLICATE

MS/MSD and matrix duplicate (MD) data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix. MD analyses are also performed to demonstrate acceptable method precision by the laboratory at the time of analysis.

MS/MSD results should be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if spiked analytes are not listed in Appendix C or project limits are not specified.

For the MD RPD, for sample results greater than 5× the LOQ, use RPD to evaluate. For sample results less than 5× the LOQ, use the difference between the MD and the sample unless project limits are specified. For difference use 1× the LOQ as the control limit for water samples and 2× the LOQ as the control limit for soil samples unless project limits are specified.

If the MS/MSD percent recovery results do not meet the control limits, further action shall be evaluated to determine the source of difference. For sample analytes greater than 50× the LOQ, a five-fold dilution test can be performed. For samples analytes less than 50× the LOQ, a post digestion spike (PDS) can be performed.

Level C and Level D:

The laboratory must spike and analyze a MS/MSD or MD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form VA. MD data should be reported on a MD summary form similar to Form VI. PDS data should be reported on a summary form similar to Form VB. The serial dilution results should be reported on a summary form similar to Form IX.
2. If the MS/MSD results are outside of the control limits and the sample results are greater than 50× LOQ and a five-fold serial dilution test was performed and the dilution results were within 10 percent difference of the original measurement, then the data is acceptable.
3. If the MS/MSD results are outside of the control limits and the sample results are less than 50x LOQ and a PDS was performed and within 80–120 percent recovery, then the data is acceptable.
4. If the MS/MSD results are not within the control limits and the secondary actions (serial dilution test and/or PDS) are outside of the control limits or not performed, the source sample requires qualification. The following guidelines are recommended:
6. If MS/MSD results are below the control limits, spiked analytes that showed low recovery shall be flagged as estimated “UJ” or “J.”
    a. If MS/MSD results are above the control limits, detects for only the spiked analytes that showed high recovery shall be flagged as “J.”
    b. If the RPD or difference between MS and MSD or between the MD and sample are greater than 20 percent, qualify the sample as estimated “UJ” or “J.” RPD results are not affected by the serial dilution test or the PDS.
    c. Failure of MS/MSD due to the presence of a target analyte in the parent sample at greater than four times the spike concentration should not result in any qualifications. Note the incident in the data validation report.

Level D:

For the MS/MSD, check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Forms VA and VB (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

For the ICP serial dilution, recalculate one or more percent difference (%Ds) from the information supplied in the raw data and compare the results to those reported on Form IX using the following equation. If discrepancies are discovered, correct Form IX and validate the associated data accordingly using the criteria outlined above.

$$\%D = \frac{(I - S)}{I} \times 100$$

Where:

I = initial sample result

S = serial dilution result (instrument reading × 5)

If transcription errors are discovered on Forms VA or VB (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.7 FURNACE ATOMIC ABSORPTION QC

Duplicate injections and furnace analytical spikes establish the precision and accuracy of the individual analytical determinations. For analyses, graphite furnace analysis is usually performed on arsenic, lead, selenium, and thallium.

Level C and Level D:

1. Prepare and analyze the sample and one spike at 2× the limit of quantitation (LOQ). If after analysis within the calibration range the spike recovery is less than 80 percent or greater than 120 percent and the sample absorbance or concentration is greater than 50 percent of the spike amount; the sample quantitation must be performed by the Method of Standard Addition (MSA). Review Form XIV. The graphite furnace atomic absorption analytical spikes should be reported for each analyte in the column labeled %R.
2. Spike recovery must be greater than or equal to 80 percent and less than or equal to 120 percent.
    a. If the analytical spike recovery is less than 80 percent, qualify results as estimated “J” or “UJ” in all associated samples.
    b. If the analytical spike recovery is less than 10 percent, qualify nondetected results as unusable “R” and detected results as estimated “J” in all associated samples.
    c. If the analytical spike recovery is greater than 120 percent, all detected data for the specific analyte will be qualified as estimated “J,” in all associated samples.
3. If MSA is required, review Form VIII.
    a. If the MSA is required and has not been done, qualify the data as estimated “J.”
    b. If any of the samples have not been spiked at the appropriate levels, qualify the data as estimated “J.”
    c. If the MSA correlation coefficient is less than 0.995, qualify the data as estimated “J.”

Note: Level C validation does not encompass the review of raw data; therefore, for sample concentrations greater than the RL, relative standard deviation (RSD), (or coefficient of variation for duplicate injections) is not evaluated. The reviewer should note in the data validation summary that this information was not reviewed.

Level D:

1. Verify by recalculating at least one analytical spike recovery per graphite furnace analyte reported on Form XIV. Also recalculate any analytical spike recovery that resulted in qualification of an analyte during Level C validation. If any transcription errors are discovered, request a resubmittal from the laboratory and validate the associated data accordingly using the criteria outlined above.
2. Verify by recalculating all graphite furnace results reported from a MSA determination, especially if the MSA was unsuccessful and resulted in qualification of the data. If any transcription errors are discovered, request a resubmittal from the laboratory and validate the associated data accordingly using the criteria outlined above.

4.8 INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY INTERNAL STANDARDS

The analysis of inductively coupled plasma-mass spectrometry internal standards determines the existence and magnitude of instrument drift and physical interferences. The criteria for evaluation of internal standard results apply to all analytical samples and method blanks analyzed during the run.

Level C and Level D:

1. Review Form XV (or equivalent) for the internal standard %R values.
2. If no internal standards were analyzed with the run, the sample data should be qualified as unusable (R).
3. If the %R is not within the 30-120 percent limit, qualify positive results as estimated “J” and nondetects as estimated “UJ.”

Level D:

Verify the internal standard %R reported on Form XV (or equivalent) from the raw data for at least one sample per sample delivery group (SDG), and verify internal standard results for samples that were qualified due to out-of-control internal standard results. If errors are discovered between the raw data and the Form XV (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.9 SAMPLE RESULT VERIFICATION

Level C:

Level C validation does not require the evaluation of raw data; sample result verification is not required. All soil sample results are reported on a dry weight basis.

Level D:

Verify by recalculating at least one ICP, GFAA, and CVAA result against the raw data for each Form I (or equivalent). Verify that the target analyte was reported from the correct run and the correct dilution factor was used. Review the laboratory preparation logs and instrument run logs to insure the accurate reporting of the data. If transcription errors are discovered, request a resubmittal from the laboratory and validate the data according the criteria outlined above.

4.10 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedure are equipment blanks, field blanks, field duplicates, and field triplicates. Analytical results for field QC samples are utilized to qualify associated sample results.

4.10.1 Equipment Blanks and Field Blanks

Analytes detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If metals are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.3.1 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the SDG.

2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to µg/L from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

1. Verify all target analytes found in the equipment blanks and field blanks against the raw data.
2. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.10.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Verify by recalculating at least two detects common between the sample and its field duplicate and/or field triplicate. If discrepancies are discovered, request a resubmittal from the laboratory.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for Wet Chemistry Analyses

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of wet chemistry parameters data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Cursory validation is addressed separately in Procedure II-A, *Data Validation*.

It covers the following parameters:

- Alkalinity (Standard Methods for the Examination of Water and Wastewater Method 2320B and U.S. Environmental Protection Agency [EPA] Method 310.1 [EPA 2007])
- Bromide, Chloride, Fluoride, Nitrate, Nitrite, Orthophosphate, and Sulfate (EPA Method Solid Waste [SW]-846 9056 and EPA Method 300.0)
- Chemical oxygen demand (EPA Method 410)
- Chloride (EPA Method 325.3)
- Chromium VI (EPA Method SW-846 7195/7196A/7197/7198/7199 and EPA method 218.6 and 218.7)
- Cyanide (EPA Method SW-846 9010B/9012A and EPA Method 335)
- Fluoride (EPA Method 340.2)
- Surfactants (M.B.A.S.) (EPA Method 425.1)
- Nitrate/Nitrite (EPA Method 353.2 and 353.3)
- Perchlorate (EPA Method 314.0)
- Phosphate (EPA Method 365.3)
- Sulfate (EPA Methods 375.3 and 375.4)
- Sulfide (EPA Method 376.1)
- Total dissolved solids (EPA Method 160.1)
- Total suspended solids (EPA Method 160.2)
- Total organic carbon (EPA Method SW-846 9060, Lloyd Kahn, and Walkley-Black)
- Total organic halides (EPA Method SW-846 Method 9020)
- Total recoverable petroleum hydrocarbons (EPA Method 418.1)
- pH (EPA Method SW-846 Method 9040 and EPA Method 150.1)
- Total hardness (Standard Methods for the Examination of Water and Wastewater Method 314A and EPA Method 130.1)

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all wet chemistry data.

4. Procedures

This procedure addresses the validation of wet chemistry parameters data obtained using EPA Method SW-846 7195/7196A/7197/7198/7199/9000, *Standard Methods for the Examination of Water and Wastewater*, 21st Edition, 2005, (APHA 2005) and EPA *Methods for Chemical Analysis of Water and Wastes*, revised March 1983 (EPA 1983). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Initial and Continuing Calibration Verification Form
- Form III: Blanks Form
- Form V: Spike Sample Recovery Form
- Form VI: Duplicates Form
- Form VII: Laboratory Control Sample Form
- Form XIII: Preparation Log Form
- Form XIV: Analysis Run Log Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly handled. All samples must be stored at less than 6 degrees Celsius (°C). Water samples for the following analyses should be preserved as listed below or as specified in the analytical method:

- Chemical Oxygen Demand (COD) – Sulfuric acid to pH < 2
- Cyanide – NaOH to pH > 12
- Nitrate/Nitrite – Sulfuric acid to pH < 2
- Sulfide – Zinc acetate and NaOH to pH > 9
- Total Recoverable Petroleum Hydrocarbons – Sulfuric or hydrochloric acid to pH < 2
- Total Phosphorus – Sulfuric acid to pH < 2
- Total Organic Carbon (TOC) - Sulfuric or hydrochloric acid to pH < 2
- Total Organic Halides (TOX) – Sulfuric acid to pH < 2
- Total Hardness – Nitric acid to pH < 2

1. Any sample improperly preserved or arriving at the laboratory in a broken container shall be noted in the data validation report. If there is no indication of chemical preservation, assume samples are unpreserved. Professional judgment may result in the results of an analysis of an inappropriately preserved sample by the laboratory being qualified as estimated "J" or "UJ." In extreme cases (a preservation destructive to the analyte of interest) the sample data may be qualified as unusable, "R."
2. If any sample arriving at the laboratory for analysis is not refrigerated or the temperature of any cooler containing samples exceeds 4 ±2°C, this shall be noted in the data validation report; however, no qualification of data will be required.
3. If the temperature of the cooler was not recorded upon its receipt at the laboratory, document that the laboratory is noncompliant.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all wet chemistry analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Verify collect dates, sampling times, and time zones. This is critical to evaluating parameters with short holding times.
2. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for wet chemistry parameters but were not requested should also be noted.
3. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
4. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
5. Internal chain of custody is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
6. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Holding times for water samples shall be those given in the most recent version of 40 Code of Federal Regulations (CFR) Part 136 or SW-846, Volume 1, Section C, if not specified in 40 CFR, art 136, or those specified in the analytical method. Holding times are determined from the time of sample collection to the time of sample analysis. Water holding times will be applied to soil/sediment samples. Current water holding times are as follows:

- Alkalinity – 14 days
- Bromide – 28 days
- COD – 28 days
- Chloride – 28 days
- Chromium (VI) – 24 hours for unpreserved water samples (14 days from lab preservation); 28 days for soil samples
- Cyanide – 14 days
- Fluoride – 28 days
- Surfactants (M.B.A.S.) – 48 hours
- Nitrate – 48 hours for water samples; 28 days for soil samples
- Nitrite – 48 hours for water samples; 28 days for soil samples
- Nitrate/Nitrite – 28 days
- Orthophosphate – 48 hours for water samples; 28 days for soil samples
- Perchlorate – 28 days

- Sulfate – 28 days
- Sulfide – 7 days
- Total Phosphorus – 28 days
- Total Dissolved Solids – 7 days
- Total Suspended Solids – 7 days
- TOC – 28 days
- TOX – 28 days (7 days if not preserved)
- Total Recoverable Petroleum Hydrocarbons – 28 days
- pH – immediate upon sampling for water samples; 28 days for soil samples
- Total Hardness – 6 months

Level C and Level D:

If holding times are exceeded, flag all results greater than the detection limit (DL) or limit of quantitation (LOQ) as estimated “J” and all results less than the DL or LOQ as estimated “UJ” and document that holding times were exceeded. If holding times are grossly exceeded, the reviewer may determine that the data reported as nondetects are unusable “R.” Data will not be qualified unusable “R” unless the holding time was exceeded by more than a factor of 2.

4.2 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory.

4.2.1 The Initial Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run.

Level C and Level D:

A blank and at least three standards must be used in establishing the analytical curve.

If the correlation coefficient is below 0.995, qualify all associated detects as estimated “J” and all nondetects as “UJ.” If the correlation coefficient is significantly lower than 0.995, professional judgment may be used to reject, “R,” the analytes associated with the initial calibration.

Level D:

Recalculate the correlation coefficient for all initial calibrations. Verify from the raw data that appropriate concentration and number of standards were utilized to establish analytical curves and the associated correlation coefficients.

4.2.2 Initial Calibration Verification (ICV) and Continuing Calibration Verification (CCV)

The working calibration curve must be verified at the interval of 10 percent to ensure that the system performance has not degraded. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory. Calibration must be verified with an independently prepared check standard.

Level C and Level D:

Review the ICV and CCV percent recovery (%R) forms. Analysis results must fall within the control limits of 90–110 percent recovery of the true value except perchlorate. Analysis results for perchlorate must fall within the control limits of 75–125 percent recovery of the true value for the ICV and 85–115 percent recovery of the true value for the CCV.

1. Due to possible rounding discrepancies, allow the results to fall within 1 percent of the acceptance windows (e.g., 89–111 percent).
2. If after a failing CCV, two additional consecutive CCVs are analyzed immediately, and both additional CCVs are within the control limits, the data is acceptable. If either of the additional CCVs is not within control limits, then the associated data will need qualification. See below for the recommended qualification guidelines.
3. If the ICV or CCV %R falls outside the acceptance windows, use professional judgment to qualify all associated data. If possible, indicate the bias in the technical review. The following guidelines are recommended:
   a. If the ICV or CCV %R falls outside the acceptance windows but within the ranges of 75–89 percent or 111–125 percent (perchlorate, 70–84 percent or 116–130 percent), qualify results greater than the DL as estimated “J.”
   b. If the ICV or CCV %R is within the range of 111–125 percent (perchlorate, 116-130 percent), results less than the DL are acceptable.
   c. If the ICV or CCV %R is 75–89 percent (perchlorate, 70–84 percent), qualify results less than the DL as nondetected and estimated “UJ.”
   d. If the ICV or CCV %R is less than 75 percent (perchlorate, less than 70 percent), qualify all results as unusable “R.”
   e. If the ICV or CCV %R is greater than 125 percent (perchlorate, greater than 130 percent), qualify results greater than the DL as unusable “R”; results less than the DL are acceptable.

Level D:

1. Recalculate and verify one or more of the ICV and CCV %Rs per type of analysis using the following equation for %R. Once again, to correct for possible rounding discrepancies, let the results fall within 1 percent of the contract windows (e.g., 89–111 percent).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Concentration (in micrograms per liter [µg/L]) of each analyte measured in the analysis of the ICV or CCV solution.

Q_a = Concentration (in µg/L) of each analyte in the ICV or CCV source.

2. If discrepancies are discovered on any form, request a resubmittal from the laboratory and validate according to the criteria outlined above.

4.3 BLANKS

Method (preparation) and calibration blank analyses results are assessed to determine the existence and magnitude of laboratory contamination problems. If problems with any blank exist, all data associated with the blank must be carefully evaluated to determine whether there is a bias on the data, or if the problem is an isolated occurrence not affecting data.

4.3.1 Calibration Blanks

Level C and Level D:

1. If the blank is less than the LOQ and the samples results are greater than the DL but less than the LOQ, then qualify “U” at the result.
2. If the blank is less than the LOQ and the sample results are greater than the LOQ or nondetect, the data is acceptable.
3. If the blank is greater than the LOQ, then samples less than 5x the blank will be qualified as “U” at the concentration. Samples greater than 5x the blank are acceptable.
4. For negative blanks where the absolute value of the blank is greater than the LOQ, sample results that are less than 10x the absolute value of the negative blank qualify “J” for detect and ‘UJ” for nondetect results. Results that are greater than 10x the absolute value of the negative blank are acceptable.

Ensure that units are correct when applying calibration blank qualifications. If samples are soil matrix, results must first be converted to µg/L from milligrams per kilogram to make correct comparisons.

Level D:

Verify one or more of the calibration blank results per type of analysis by comparing the Form III to the raw data. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.3.2 Method (Preparation) Blanks

Level C and Level D:

At least one method blank must be prepared with each batch of samples. If a method blank was not prepared and analyzed as required, the reviewer may qualify associated sample results less than the DL as nondetected and estimated “UJ,” and sample results greater than the MDL as estimated “J.”

Professional judgment should be utilized, however, taking into account the results of other associated blanks (e.g., initial calibration blank, continuing calibration blank).

If analytes of interest are detected in the method blanks, the procedure for the qualification of associated sample results is identical to the rules outlined in Section 4.3.1 of this procedure.

Level D:

Verify out-of-control method blanks that result in the qualification of numerous analytes against the raw data. Verify the results reported on Form III. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.4 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QSM Appendix C limits specified in the DoD QSM unless project-specific control limits are established for a given sample matrix. Use in-house limits if analytes are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are less than 50 percent, only the spiked analytes that showed low recovery in all associated samples shall be flagged as “R” for nondetects and “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 50 percent), spiked analytes that showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked analytes that showed high recovery in all associated samples shall be flagged as “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To check that the spike %R was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form VII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.5 MATRIX SPIKE/MATRIX SPIKE DUPLICATE AND MATRIX DUPLICATE

MS/MSD and matrix duplicate (MD) data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix. MD analyses are also performed to demonstrate acceptable method precision by the laboratory at the time of analysis.

If the MS/MSD and MD results do not meet the technical criteria, apply the action to the source sample only.

MS/MSD results should be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if spiked analytes are not listed in Appendix C or project limits are not specified.

For the MD RPD, samples greater than 5× the LOQ use RPD to evaluate. For samples less than 5× the LOQ, use the difference between the MD and the sample unless project limits are specified. For difference use 1× the LOQ as the control limit for water samples and 2× the LOQ as the control limit for soil samples unless project limits are specified.

Level C and Level D:

1. The laboratory must spike and analyze a MS/MSD or MD from the specific project site as required for each matrix type and analytical batch.
2. MS/MSD data should be reported on a MS/MSD summary form similar to Form V. MD data should be reported on a MD summary form similar to Form VI.
3. If MS/MSD results are below the control limits, spiked analytes that showed low recovery shall be flagged as estimated "UJ" or "J."
4. If MS/MSD results are above the control limits, detects for only the spiked analytes that showed high recovery shall be flagged as "J."
5. If the RPD between MS and MSD recoveries or the RPD or difference between the MD and sample are greater than 15 percent, qualify the sample as estimated "UJ" or "J."
6. Failure of MS/MSD due to the presence of a target analyte in the parent sample at greater than four times the spike concentration should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs, especially %Rs that resulted in the qualification of data, using the following equation to verify that results on Forms V and VI (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added
SR = sample result
SSR = spiked sample result
SDR = spiked duplicate result
ABS = absolute value

If transcription errors are discovered on Forms V or VI (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SAMPLE RESULT VERIFICATION

Level C:

Level C validation does not require the evaluation of raw data, sample result verification is not required. All soil sample results are reported on a dry weight basis.

Level D:

The raw data should be examined to verify that the correct calculation of the sample results was reported by the laboratory. Sample preparation logs, instrument printouts, strip charts, etc. should be compared to the reported sample results recorded on the sample results summary forms. All soil sample results are reported on a dry weight basis.

1. Evaluate the raw data for any anomalies (i.e., baseline shifts, negative absorbance, omissions, legibility).
2. Verify that there are no errors in transcription or calculation. If errors are discovered, request a resubmittal from the laboratory and validate the data according the criteria outlined above.
3. Verify that results fall within the calibrated range. If the positive sample result falls outside the calibrated range, qualify the sample result "J."

4.7 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedure are equipment blanks, field blanks, field duplicates, and field triplicates. Analytical results for field QC samples are utilized to qualify associated sample results.

4.7.1 Equipment Blanks and Field Blanks

Analytes detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If analytes are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.3.1 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group.
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to μg/L from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

1. Verify all target analytes found in the equipment blanks and field blanks against the raw data.
2. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.7.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.

2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Verify by recalculating at least two detects common between the sample and its field duplicate and/or field triplicate. If discrepancies are discovered, document in the data validation report.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years.

6. References

American Public Health Association (APHA). 2005. *Standard Methods for the Examination of Water and Wastewater*. 21st ed. Washington. September.

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Data Quality Assessment Report

1. Purpose

This procedure describes the presentation format and information provided in the data quality assessment report (DQAR) under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). The objective of DQAR is to summarize the validated data to the end user. This procedure also establishes the method by which a Contract task Order (CTO) Manager selects and confirms the content of the DQAR. Data validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel (unless otherwise stated) are responsible for implementing this procedure for all DQARs.

4. Procedure

4.1 INTRODUCTION

The DQAR summarizes the QA/quality control (QC) evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity relative to the project quality objectives (PQOs). The report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR summary report identifies the level of data validation for each sample and evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. The last section presents a summary of the precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative criteria are also summarized in this section. A DQAR example is provided as Attachment II-S-1.

4.2 PRECISION AND ACCURACY OF ENVIRONMENTAL DATA

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QC samples include: trip blanks, equipment blanks, field blanks, field duplicates, field triplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), laboratory duplicates, and laboratory triplicates.

Before producing the DQAR, the analytical data should be validated according to the NAVFAC Pacific data validation procedures. Samples not meeting the NAVFAC ER Program validation criteria are qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

J Estimated. The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The "J" qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.

R Rejected. The data is unusable (the compound or analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.

U Nondetected. Analyses were performed for the compound or analyte, but it was not detected. The "U" designation is also applied to suspected blank contamination. The "U" flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants.

UJ Estimated/Nondetected. Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery.

Once the data are reviewed and qualified according to the NAVFAC Pacific data validation procedures, the data set is then evaluated using precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria that provide an evaluation of overall data usability. The following is a discussion of the precision, accuracy, representativeness, completeness, and comparability criteria as related to the PQOs.

4.2.1 Precision

Precision is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD) or percent relative standard deviation (%RSD):

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

$$\%\text{RSD} = \text{SD}/\{1/3(\text{D1}+\text{D2}+\text{D3})\} \times 100$$

Where:

D1 = the reported concentration for primary sample analyses

D2 = the reported concentrations for duplicate analyses

D3 = the reported concentrations for triplicate analyses

SD = the standard deviation for sample, duplicate and triplicate analyses

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory duplicate or LCS/laboratory control sample duplicate (LCSD) pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple sample delivery groups (SDGs) are within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision may be obtained by collecting and analyzing field duplicate samples, which are compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganic analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate and calculates RPDs to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

If incremental sampling is performed, laboratory and field sampling precision are evaluated by calculating RSDs for laboratory triplicates and field triplicates. At the subsampling step, one sample is prepared in triplicate per batch. Laboratory triplicate data are used to determine that the samples are being reduced to sufficiently small particle sizes during the grinding process. Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD or a %RSD outside the numerical QC limit in the laboratory triplicate indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicates and/or triplicates, results may be reported in the primary, duplicate, or triplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from duplicates or %RSD exceedances from triplicates do not suggest a significant impact on the data quality.

4.2.2 Accuracy

Accuracy is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs are within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

Percent recovery (%R) is calculated using the following equation:

$$\%R = (A-B)/C \times 100$$

Where:

A = measured concentration in the spiked sample
B = measured concentration of the spike compound in the unspiked sample
C = concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

4.3 REPRESENTATIVENESS

Representativeness is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The various types of blanks evaluated are discussed below.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12-hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample volatile organics analysis vial filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event.

If sample grinding is performed, grinding blanks, which consist of clean solid matrix (such as Ottawa sand), must be prepared (e.g., ground and subsampled) and analyzed in the same manner as a field sample. Grinding equipment must be thoroughly cleaned between the processing of samples and grinding blanks must be processed and analyzed to prevent cross-contamination.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank value for common laboratory contaminants (methylene chloride, acetone, 2-butanone, and phthalate esters) or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

4.4 COMPARABILITY

Comparability is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability can only be compared with confidence when precision, accuracy, and representativeness are known.

4.5 COMPLETENESS

Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. The goal for completeness for target analytes in each analytical fraction should be specified in the DoD QSM (DoD 2013) or project planning document.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

$\%C$ = percent completeness

T = total number of sample results

R = total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

4.6 SENSITIVITY

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the data quality objectives (DQOs). It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

5. References

Department of Defense, United States (DoD). 2013. *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories.* Final version 5.0. Prepared by Department of Defense Environmental Data Quality Workgroup and the Department of Energy Consolidated Audit Program Operations Team. March.

Procedure II-A, *Data Validation*.

6. Attachments

II-S-1: Data Quality Assessment Report Example

Attachment II-S-1
Data Quality Assessment Report Example

DATA QUALITY ASSESSMENT REPORT

SITE INVESTIGATION BUILDING E-13
PEARL HARBOR, CTO XXX

12/1/03

Table of Contents

Glossary

μg/kg	microgram per kilogram
μg/L	microgram per liter
BTEX	benzene, toluene, ethylbenzene, xylenes
DL	detection limit
DQO	data quality objectives
EPA	Environmental Protection Agency, United States
IDL	instrument detection limit
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
LOD	limit of detection
LOQ	limit of quantitation
mg/kg	milligram per kilogram
MS/MSD	matrix spike/matrix spike duplicate
NAS	Naval Air Station
PARCCS	Precision, Accuracy, Representativeness, Comparability, Completeness, Sensitivity
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
QA/QC	quality assurance/quality control
RPD	relative percent difference
RRF	relative response factor
RL	reporting limit
SDG	sample delivery group
%D	percent difference
%R	percent recovery
%RSD	percent relative standard deviation

1. Introduction

A remediation and closure was conducted at Building E-13 at Pearl Harbor, Oahu, Hawaii. This part of the site investigation included the collection and analyses of 141 environmental and quality control (QC) samples. The analyses were performed by the following methods:

- Polynuclear aromatic hydrocarbons (PAHs) by United States Environmental Protection Agency (EPA) SW-846 8270C-SIM
- Polychlorinated biphenyls (PCBs) by EPA SW-846 Method 8082
- Metals by EPA SW-846 Method 6010B/6020/7471A

Analytical services were provided by ZZZZ Laboratories whom performed analyses on the water and soil samples. The samples were grouped into sample delivery groups (SDGs) of up to 20 field samples received by each laboratory. The environmental samples are associated with QA/QC samples designed to document the data quality of the entire SDG or a sub-group of samples within a SDG. Table I is a cross-reference table listing each sample, analysis, SDG, collection date, laboratory sample number, and matrix. All shaded samples in Table I were reviewed under Level D validation guidelines.

One hundred percent of the analytical data were validated according to NAVFAC Pacific Level D data validation procedures. The analytical data were evaluated for quality assurance and quality control (QA/QC) based on the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006).

This data quality assessment report (DQAR) summarizes the QA/QC evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) relative to the project quality objectives (PQOs). This report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the PARCC criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. Section 6 presents a summary of the PARCC criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative PARCC criteria are also summarized in this section.

Precision and Accuracy of Environmental Data

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QA/QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QA/QC samples include: equipment blanks, field duplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), and laboratory duplicates.

Before conducting the PARCC evaluation, the analytical data were validated according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* [2006]). Samples not meeting the Project Procedures Manual acceptance criteria were qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

J	<u>Estimated</u>: The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The “J” qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.
R	<u>Rejected</u>: The data is unusable (the compound or analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.
U	<u>Nondetected</u>: Analyses were performed for the compound or analyte, but it was not detected. The "U" designation is also applied to suspected blank contamination. The "U" flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants.
UJ	<u>Estimated/Nondetected</u>: Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery.

Once the data are reviewed and qualified according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006), the data set is then evaluated using PARCCS criteria. PARCCS criteria provide an evaluation of overall data usability. The following is a discussion of PARCCS criteria as related to the PQOs.

Precision is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD):

$$RPD = (D1–D2)/\{1/2(D1+D2)\} \times 100$$

Where:

D1 and D2 = the reported concentrations for sample and duplicate analyses.

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory duplicate or LCS/LCSD pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision was obtained by collecting and analyzing field duplicate samples, which were compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials (ASTM) for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganics analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate, then calculates RPDs, which are used to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for aqueous field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicate pairs, results maybe reported in either the primary or duplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from these duplicate pairs do not suggest a significant impact on the data quality.

Accuracy is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for all applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

%R is calculated using the following equation:

$$\%R = (A - B)/C \times 100$$

Where:

A = measured concentration in the spiked sample

B = measured concentration of the spike compound in the unspiked sample

C = concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

Representativeness is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The QA/QC blanks collected and analyzed are method blanks.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12 - hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample bottle filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure. Equipment blanks were collected and analyzed for all target analytes.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event. Field blanks were collected and analyzed for all target analytes.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank value for common laboratory contaminants; methylene chloride, acetone, 2-butanone, and phthalate esters or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

Comparability is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability is also dependent upon other PARCC criteria, because only when precision, accuracy, and representativeness are known can data sets be compared with confidence.

Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. As specified in the PQOs, the goal for completeness for target analytes in each analytical fraction is 90 percent.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

$\%C$ = percent completeness

T = total number of sample results

R = total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the DQOs. It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

The following sections present a review of QC data for each analytical method.

2. Polynuclear Aromatic Hydrocarbons

A total of 58 soil samples were analyzed for PAH by EPA SW-846 Method 8270C-SIM. All PAH data were assessed to be valid with the exception of 17 of the 986 total results, which were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

2.1 PRECISION AND ACCURACY

2.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Relative response factor (RRF), percent relative standard deviation (%RSD), and percent difference (%D) are the three major parameters used to measure the effectiveness of instrument calibration. RRF is a measure of the relative spectral response of an analyte compared to its internal standard. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest routine instrumental anomalies, which typically impact all sample results for the affected compounds.

The relative response factors met the acceptance criteria of 0.05 in the initial and continuing calibration standards.

The relative standard deviation in the initial calibrations and/or %D between the initial calibration mean relative response factors and the continuing calibration relative response factors were within the acceptance criteria of 15 and 20 percent, respectively.

The %Ds in the initial calibration verification were within the acceptance criteria of 20 percent.

2.1.2 Surrogates

As a result of non-compliant surrogate recoveries, 17 non-detected results in sample BA368 were qualified as unusable (R). Additionally, 136 results in samples BA267, BA338, BA341, BA363, BA364, BA367, BA368, and BA369 were qualified as detected estimated (J) and non-detected estimated (UJ) due to non-compliant surrogate recoveries. The details regarding the qualification of results are provided in the data validation reports.

2.1.3 MS/MSD Samples

As a result of non-compliant MS/MSDs, five results for non-compliant RPDs and 32 results for non-compliant %Rs were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were 2-methylnapthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluorene, naphthalene, phenanthrene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

2.1.4 LCS Samples

As a result of non-compliant LCS/LCSD recoveries, 139 results were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were acenaphthene, benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, fluorene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

2.1.5 Internal Standards

No data were qualified based on internal standard nonconformances. The recoveries and retention times were evaluated against the acceptance criteria.

2.1.6 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

2.1.7 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

2.1.8 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., co-elution of peaks), 29 benzo(b)fluoranthene and benzo(k)fluoranthene detected results in several samples were qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable

2.2 REPRESENTATIVENESS

2.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

2.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic compounds based on the following criteria. The validation qualifier codes used in the blank summary tables are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less than 5× the blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.
- *No Action:* If a sample result for the blank contaminant was greater than 10× the blank value for common contaminants or 5× the blank value for other contaminants, the result was not amended.

2.2.2.1 METHOD BLANKS

As a result of method blank contamination, one benzo(a)anthracene result was qualified as non-detected (U). The details regarding the qualification of results are provided in the data validation reports.

2.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

2.4 COMPLETENESS

The completeness level attained for PAH field samples was 98.3 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

2.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory reporting limits met the specified requirements described in the work plan although LOD was elevated for benzo(a)anthracene for one sample due to method blank contamination.

3. Polychlorinated Biphenyls

A total of 20 soil samples were analyzed for PCB as Aroclors by EPA SW-846 Method 8082. All PCB data were assessed to be valid since none of the 140 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

3.1 PRECISION AND ACCURACY

3.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Percent relative standard deviation (%RSD) and percent difference (%D) are the two major parameters used to measure the effectiveness of instrument calibration. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected compounds.

Six results were qualified detected estimated (J) and non-detected estimated (UJ). The relative standard deviations in the initial calibrations and/or percent difference between the initial calibration and the continuing calibration concentrations for Aroclor 1016, Aroclor 1221, and Aroclor 1232 were outside the acceptance criteria of 20 and 15 percent, respectively. The affected samples are identified in the data validation reports.

3.1.2 Surrogates

No data were qualified based on surrogate recovery nonconformances. In cases where individual recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

3.1.3 MS/MSD Samples

No data were qualified based on MS/MSD nonconformances. For those SDGs with MS/MSD results, the recoveries were evaluated against the acceptance criteria. In cases where recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

3.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

3.1.5 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

3.1.6 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

3.1.7 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., %Ds between columns), one Aroclor 1260 result in sample BA245 was qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable.

3.2 REPRESENTATIVENESS

3.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

3.2.2 Blanks

As previously discussed in Section 2.2.2, method blanks were analyzed to evaluate representativeness.

3.2.2.1 METHOD BLANKS

No QC issues were associated with the method blanks for this analysis.

3.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

3.4 COMPLETENESS

The completeness level attained for PCB field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

3.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

4. Metals

A total of 48 soil samples were analyzed for metals by EPA SW-846 Method 6010B/6020/7471A. All metals data were assessed to be valid since none of the 465 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

4.1 PRECISION AND ACCURACY

4.1.1 Instrument Calibration

Initial and continuing calibration verification results provide a means of evaluating accuracy within a particular SDG. Correlation coefficient (r) and percent recovery (%R) are the two major parameters used to measure the effectiveness of instrument calibration. The correlation coefficient indicates the linearity of the calibration curve. %R is used to verify the ongoing calibration acceptability of the analytical system. The most critical of the two calibration parameters, r, has the potential to affect data accuracy across a SDG when it is outside the acceptable QC limits. %R exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected analytes.

The correlation coefficients in the initial calibrations and/or percent recoveries in the continuing calibration verifications were within the acceptance criteria of $\geq$ 0.995 and 90-110 percent, respectively.

4.1.2 MS Samples

As a result of non-compliant MS recoveries, 21 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were barium, cadmium, and chromium. The details regarding the qualification of results are provided in the data validation reports.

4.1.3 Duplicate (DUP) Samples

No data were qualified based on duplicate nonconformances. For those SDGs with DUP results, the relative percent differences/differences were evaluated against the acceptance criteria. In cases where

RPDs or differences exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

4.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

4.1.5 ICP Serial Dilution

No data were qualified based on ICP serial dilution nonconformances. All recoveries were evaluated against the acceptance criteria.

4.1.6 ICP Interference Check Sample

As a result of ICP interference check sample exceedances, 16 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were arsenic, cadmium, chromium, and silver. The details regarding the qualification of results are provided in the data validation reports.

4.1.7 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the analytes. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

4.1.8 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

4.1.9 Sample Result Verification

All sample results were found to be acceptable.

4.2 REPRESENTATIVENESS

4.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

4.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic analytes based on the following criteria. The validation qualifier codes are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less 5× the method blank value or the highest applicable calibration blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.

- *No Action:* If a sample result for the blank contaminant was greater than 5× the blank value, the result was not amended.

4.2.2.1 METHOD BLANKS

No QC issues were associated with the method blanks for this analysis.

4.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target analytes detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

4.4 COMPLETENESS

The completeness level attained for metal field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

4.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

5.0 Variances in Analytical Performance

The laboratory used standard analytical methods for all of the analyses throughout the project. No systematic variances in analytical performance were noted according to the laboratory SOW.

6.0 Summary of PARCC criteria

The validation reports present the PARCC results for all SDGs. Each PARCC criterion is discussed in detail in the following sections.

6.1 PRECISION AND ACCURACY

Precision and accuracy were evaluated using data quality indicators such as MS/MSD, LCS, and surrogates. The precision and accuracy of the data set were considered acceptable after integration of qualification of estimated results as specifically noted in the data validation reports.

6.2 REPRESENTATIVENESS

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

6.3 COMPARABILITY

Sampling frequency requirements were met in obtaining duplicates and necessary field blanks. The laboratory used standard analytical methods for their analyses. The analytical results were reported in correct standard units. Holding times, sample preservation, and sample integrity were within QC criteria. The overall comparability is considered acceptable.

6.4 COMPLETENESS

Of the 1591 total analytes reported, 17 of the sample results were rejected. The completeness for all SDGs is as follows:

Parameter/Method	Total Analytes	No. of Rejects	%Completeness
PAHs	986	17	98.3
PCBs	140	0	100
Metals	465	0	100
Total	**1,591**	**17**	**98.9**

The completeness percentage based on rejected data met the 90 percent DQO goal. A less quantifiable loss of data occurred in the application of blank qualifications.

6.5 SENSITIVITY

Sensitivity was achieved by the laboratory to support the DQOs. Calibration concentrations and reporting limits met the project requirements and low level PAH contamination in the method blanks did not affect sensitivity.

Table 1: Validation Sample Table, SDG 42300

Client ID #	Lab ID #	QC Type	Matrix	Date Collected	Mercury (7470A)	PAH (8270C-SIM)	PCBs (8082)
BA268	AP55206		soil	7-30-03	X		
BA269	AP55207		soil	7-30-03	X		
BA270	AP55208		soil	7-30-03	X		
BA271	AP55209		soil	7-30-03	X		
BA272	AP55210		soil	7-30-03	X		
BA273	AP55211		soil	7-30-03	X		
BA274	AP55212		soil	7-30-03	X		
BA275	AP55213		soil	7-30-03	X		
BA276	AP55214		soil	7-30-03	X		
BA277	AP55215		soil	7-30-03	X		
BA278	AP55216		soil	7-31-03	X		
BA279	AP55217		soil	7-31-03	X		
BA280	AP55218		soil	7-31-03	X		
BA281	AP55219		soil	7-31-03	X		
BA282	AP55220		soil	7-31-03	X		
BA283	AP55221		soil	7-31-03	X		
BA284	AP55222		soil	7-31-03	X		
BA285	AP55223		soil	7-31-03	X		
BA286	AP55224		soil	7-31-03	X		
BA287	AP55225		soil	7-31-03	X		
BA245	AP54789		soil	7-25-03			X
BA246	AP54790		soil	7-25-03			X
BA247	AP54791		soil	7-25-03			X
BA248	AP54792		soil	7-25-03			X
BA249	AP54793		soil	7-25-03			X
BA250	AP54794		soil	7-25-03			X
BA251	AP54795		soil	7-25-03			X
BA252	AP54796		soil	7-25-03			X
BA253	AP54797		soil	7-25-03			X
BA254	AP54798		soil	7-25-03			X
BA255	AP54799		soil	7-25-03			X
BA256	AP54800		soil	7-25-03			X
BA257	AP54801		soil	7-25-03			X
BA258	AP54802		soil	7-25-03			X
BA259	AP54803		soil	7-25-03			X
BA260	AP54804		soil	7-25-03			X
BA261	AP54805		soil	7-25-03			X
BA262	AP54806		soil	7-25-03			X
BA263	AP54807		soil	7-25-03			X
BA264	AP54808		soil	7-25-03			X
BA265	AP54809		soil	7-26-03		X	
BA265DL	AP54809DL	DL	soil	7-26-03		X	

Client ID #	Lab ID #	QC Type	Matrix	Date Collected	Mercury (7470A)	PAH (8270C-SIM)	PCBs (8082)
BA266	AP54810		soil	7-26-03		X	
BA266DL	AP54810DL	DL	soil	7-26-03		X	
BA266DL2	AP54810DL2	DL2	soil	7-26-03		X	
BA267	AP54811		soil	7-26-03		X	
BA245MS	AP54789MS	MS	soil	7-25-03			X

Laboratory QC Samples (Water, Soil)

1. Purpose

This section sets forth the standard operating procedure for identifying the number and type of laboratory quality control (QC) samples that will be analyzed during each contract task order (CTO) associated with the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific. Laboratory QC analyses serve as a check on the precision and accuracy of analytical methods and instrumentation, and the potential contamination that might occur during laboratory sample preparation and analyses. Laboratory QC analyses include blank, surrogate, blank spike, laboratory control sample (LCS), and matrix spike (MS)/matrix spike duplicate (MSD) analyses. These laboratory QC analyses are discussed in general below.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 PRECISION

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as a standard deviation, variance, or range, in either absolute or relative terms. Examples of QC measures for precision include laboratory duplicates, laboratory triplicates, and matrix spike/matrix spike duplicates.

3.2 ACCURACY

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias), components which are due to sampling and analytical operations. Examples of QC measures for accuracy include performance evaluation samples, matrix spikes, LCSs, and equipment blanks.

3.3 MATRIX

A specific type of medium (e.g., surface water, drinking water), in which the analyte of interest may be contained. Medium is a substance (e.g., air, water, soil), which serves as a carrier of the analytes of interest (EPA 2010).

3.4 METHOD BLANK

An analyte-free matrix (water, soil, etc.) subjected to the entire analytical process to demonstrate that the analytical system itself does not introduce contamination.

3.5 MATRIX SPIKE

A sample prepared by adding a known concentration of a target analyte to an aliquot of a specific homogenized environmental sample for which an independent estimate of the target analyte concentration is available. The MS is accompanied by an independent analysis of the unspiked aliquot of the environmental sample. Spiked samples are used to determine the effect of the matrix on a method's recovery efficiency.

3.6 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

A sample of known composition prepared using reagent-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is analyzed using the sample preparation, reagents, and analytical methods employed for regular samples.

3.7 SURROGATES

A pure substance with properties that mimic the analyte of interest (organics only). Surrogates are typically brominated, fluorinated, or isotopically labeled compounds unlikely to be found in environmental samples. These analytes are added to samples to evaluate analytical efficiency by measuring recovery.

3.8 INTERNAL STANDARDS

A pure substance added to both samples and laboratory standards at a known concentration with the purpose of providing a basis of comparison in the quantitation of analytes of interest. Internal standards are primarily used to increase the accuracy and precision of analytical methods where the primary source of variability is in sample preparation or sample injection on instrument.

4. Responsibilities

The prime contractor's QA Manager or Technical Director, as well as QC coordinators are responsible for ensuring that sample analytical activities during all CTOs are in compliance with this procedure.

The CTO QC Coordinators and the Laboratory Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future laboratory analytical activities are in compliance with it.

5. Procedures

Laboratory QC checks include all types of samples specified in the requested analytical methods, such as the analysis of laboratory blank, duplicate, and MS samples. QC requirements are specified in each analytical method and in Appendix B, *Quality Control Requirements*, and Appendix C, *Laboratory Control Sample (LCS) Control Limits and Requirements*, of the *Department of Defense Quality Systems Manual for Environmental Laboratories* Version 5.0 (or most current version)

(DoD QSM). Types of QC samples are discussed in general below. Detailed discussion and minimum QA/QC requirements are presented in the DoD QSM (DoD 2013).

A comprehensive discussion of the minimum number of laboratory QC samples can be found in the *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (DoD 2005b). However, additional QA/QC samples may be necessary based on the project quality objectives. Information pertaining to laboratory QC samples shall be documented in Worksheet 28 Laboratory QC Samples Table of the project UFP QAPP-style planning document.

5.1 LABORATORY BLANKS

Laboratory blank samples are analyzed to assess the degree to which laboratory contamination by reagent or method preparation may have affected sample analytical results. At a minimum, one laboratory blank will be analyzed per matrix per analytical method for each batch of at most 20 samples. In evaluating the blank results, all blank data are reviewed to identify any compounds detected in the blanks. The laboratory shall be contacted to discuss detection of analytes in blank samples only in the event of unusual contamination, but not for common laboratory contaminants at low levels. The following compounds are considered to be common laboratory contaminants: acetone, methylene chloride, 2-butanone, and common phthalate esters. The data for samples analyzed during the same time period as the blank are then evaluated to identify the presence of any contaminants found in the blanks. The presence of the blank contaminants found in associated samples is then evaluated to avoid potential misinterpretation of actual sample constituents. Briefly, as discussed in the data validation procedures, any analyte detected above the LOQ in both the sample and the associated blank is qualified as not detected if the sample concentration is less than five times the blank concentration (5× rule). For common laboratory contaminants (methylene chloride, acetone, 2-butanone, and common phthalate esters), a 10× rule applies.

5.2 LABORATORY REPLICATES (DUPLICATES AND TRIPLICATES)

Replicates are analyzed to evaluate the reproducibility, or precision, of the analytical procedures for a given sample. A replicate is two (duplicates) or three (triplicates) representative portions taken from one homogeneous sample by the laboratory and analyzed in the same laboratory (DoD 2005a). One duplicate sample is analyzed for each batch of twenty samples analyzed in a given matrix. Lab triplicates are assigned by the field team and identified on the chain of custody. The identification of a sample for lab triplicate analysis is typically selected from one of the field triplicates to allow for the evaluation of total study error of the sampling and analysis process. Duplicate analyses are normally performed on sample portions analyzed for inorganic constituents. For organic analyses, duplicate analyses are performed on MS samples (Section 5.5 of this procedure).

5.3 SURROGATES

Surrogate compounds must be added to all samples, standards, and blanks for all organic chromatography methods except when the matrix precludes its use or when a surrogate is not available. Poor surrogate recovery may indicate a problem with the sample composition and shall be reported to the client whose sample produced the poor recovery. Surrogate compounds to be included for organic analysis are specified in each analytical method.

5.4 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

LCSs are used to demonstrate that the laboratory process for sample preparation and analysis is under control.

Analytes selected for spiking of LCSs are usually the same compounds used to spike MS/MSD samples and are representative target compounds. Control limits for LCS recoveries are provided in Appendix C of DoD QSM. If no control limits for LCS recoveries are listed in Appendix C of the DoD QSM for a given analyte, the laboratory's in-house derived control limits should be used.

For wet chemistry methods, a single spike of an appropriate control for each method may be used for LCS analyses (i.e., cyanide, a control standard of sodium cyanide from a source other than that used for calibration may be spiked into water samples and analyzed with the water samples). LCSs should be analyzed at a frequency of one per batch of at most twenty samples analyzed of similar matrix.

5.5 MATRIX SPIKES/MATRIX SPIKE DUPLICATES

MS analyses are conducted by the laboratory to assess the accuracy of specific analytical methods and to provide information on the effect of the sample matrix on the analytical methodology. Spike analyses are performed by adding compounds of known concentration to a sample, an unspiked portion of which has previously been analyzed or is concurrently analyzed. The spiked analytes are representative target compounds for each analytical method performed. The spiked sample results are evaluated with the original sample results to evaluate any effects the matrix has on the analysis. One MS is analyzed for each batch of at most 20 samples of similar matrix. Since MS samples only provide information about the specific sample matrix used for the spike, MS analyses should be performed for each type of matrix collected.

For the MSD, a separate aliquot of the sample is separately spiked and analyzed. As discussed in Section 5.2, results of MSD analyses are expressed as a relative percent difference, which is calculated by dividing the difference in concentration between the MSD and the MS sample analyses by the arithmetic mean of their concentrations. One MSD analysis is required for at most each 20 samples of similar matrix.

Acceptance criteria for both the MS and the MSD are based on historic laboratory performance and are laboratory-specific. As a general rule, the acceptance criteria should be no more stringent than the LCS acceptance criteria.

It is important to note that the UFP QAPP Part 2B, QA/QC Compendium: Minimum QA/QC Activities (DoD 2005b) states that for organic analysis, MS and MSDs are not considered a minimum QC activity as long as surrogate spikes properly mimic the analytes of concern and can identify matrix effects. Project quality objectives should be evaluated to determine if organic MS/MSDs are useful for individual projects.

6. Records

Records of QC samples analyzed during ER Program CTO activities will be maintained on laboratory bench sheets, raw data sheets, in the laboratory computerized data system, and on QC summary forms, as requested. Analytical laboratories maintain records in accordance with their quality assurance manual (QAM) as part of performing environmental analytical work under DoD.

Records shall be maintained in accordance with the analytical laboratory subcontract agreement specifications or the laboratory-specific QAM, whichever is more stringent.

7. Health and Safety

Applicable to laboratory personnel only.

8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2010. Environmental Monitoring and Assessment Program: QA Glossary. November 8. On-line updates available at: http://www.epa.gov/emfjulte/html/pubs/docs/resdocs/qa_terms.html#mm. Accessed 2015.

Procedure I-A-7, *Analytical Data Validation Planning and Coordination.*

9. Attachments

None.

Field QC Samples (Water, Soil)

1. Purpose

This standard operating procedure describes the number and types of field quality control (QC) samples that will be collected during United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific site field work.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the Contract Task Order (CTO) Manager and the Quality Assurance (QA) Manager or Technical Director, as well as QC coordinators responsible for compliance with the procedure. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 TRIP BLANK

Trip blanks are samples that originate from organic-free water (e.g., ASTM Type II water, high performance liquid chromatography grade water, etc.) prepared by the laboratory, shipped to the sampling site, and returned to the laboratory with samples to be analyzed for volatile organic compounds (VOCs). Trip blanks are analyzed to assess whether contamination was introduced during sample shipment (DoD 2005a). Trip blanks are prepared using the same sample container (typically a 40 ml VOA vial) as that used to collect field samples.

3.2 EQUIPMENT BLANK SAMPLES

An equipment blank (i.e., “decontamination rinsate,” or “equipment rinsate”) sample consists of a sample of water free of measurable contaminants poured over or through decontaminated field sampling equipment that is considered ready to collect or process an additional sample. Equipment blanks are to be collected from non-dedicated sampling equipment to assess the adequacy of the decontamination process.

3.3 FIELD BLANKS

A blank used to provide information about contaminants that may be introduced during sample collection, storage, and transport. It can also be a clean sample carried to the sampling site, exposed to sampling conditions, transported to the laboratory, and treated as an environmental sample.

3.4 FIELD DUPLICATE

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

3.5 FIELD REPLICATES

Two or more field replicates are used with incremental sampling approaches to statistically evaluate the sampling precision or error for each decision unit (DU). The location of the replicates (distance and direction from primary sample) and the number of DUs with replicates should be specified in the project planning documents. Increments for replicate samples are collected from completely separate locations (i.e., separate systematic random or stratified random grid). Triplicate samples (i.e., primary incremental sample plus two replicates) are required for incremental sampling and are more useful than just duplicates for statistical evaluation. The replicate samples are collected, prepared, and analyzed in the same manner as carried out for the primary sample.

3.6 TEMPERATURE INDICATORS (BLANKS)

A temperature indicator sample is often referred to as a temperature blank, but it is not analyzed nor does it measure introduced contamination. It may be a small sample bottle or VOA vial filled with distilled water that is placed in each shipping container to evaluate if samples were adequately cooled during sample shipment.

3.7 SOURCE WATER

Source water is water free from measurable contaminants that is used as the final decontamination rinse water.

4. Responsibilities

The prime contractor CTO Manager and QA Manager or Technical Director are responsible for ensuring that field QC samples are collected and analyzed according to this procedure. The CTO Manager is responsible for ensuring that all personnel involved in sampling or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QC Coordinator is responsible for determining the QC sample requirements.

The Laboratory Manager is responsible for ensuring that field QC samples are analyzed according to the specifications of the project statement of work and the analytical methods used.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

Field QC checks may include submission of trip blank, equipment blank, field blank, duplicate, triplicate, and temperature indicator (blank) samples to the laboratory. Types of field QC samples are discussed in general below. Table III-B-1 identifies the minimum frequency at which field QC samples should be collected, with the actual frequency to be determined by the individual project needs. For additional information on field QC frequency, see the State of Hawaii Department of Health 2009 *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*.

A comprehensive discussion of the minimum types and numbers of field QC samples can be found in the *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (DoD 2005).

Table III-B-1: Field QC Samples per Sampling Event

	Minimum QC Sample Frequency	
Type of Sample	Metals	Organic
Trip blank (for volatiles only)	N/A	1/analytical method/cooler
Equipment blank	5%	5%
Field blank	1/decontamination water source/event [a]/for all analytes	
Field replicates [b]	10%	10%
Temperature Indicator (blank)	1/shipping container	

% percent
N/A not applicable

[a] A sampling event is considered to be from the time sampling personnel arrive at a site until they leave for more than a week. The use of controlled-lot source water makes one sample per lot, rather than per event, an option.

[b] To the extent practical, field replicates should be collected from the same locations as the samples designated for a laboratory matrix spike/matrix spike duplicate (organic analysis) where applicable, or from the sample used as a laboratory duplicate (inorganic analysis).

5.1 TRIP BLANKS

The laboratory prepares trip blanks using organic-free water, and then sends them to the field. The laboratory shall place trip blanks in sample coolers prior to transport to the site so that they accompany the samples throughout the sample collection/handling/transport process. Once prepared, trip blanks should not be opened until they reach the laboratory. One set of two 40-milliliter vials per volatile analysis forms a trip blank and accompanies each cooler containing samples to be analyzed for volatiles. Trip blanks are only analyzed for volatiles. Results of trip blank analyses are used to assess whether samples have been contaminated by volatiles during sample handling and transport to the laboratory.

Trip blanks are not typically associated with tissue samples; however, project-specific quality objectives shall determine if trip blanks for tissue samples are required.

5.2 EQUIPMENT BLANK SAMPLES

Collect equipment blank samples by pumping the source water over and/or through the decontaminated sampling equipment. Collect this runoff water into the sample containers directly or with the use of a funnel, if necessary. The source water may be pumped or poured by tipping the jug of water upside down over the equipment. Results of equipment blank samples are used to evaluate whether equipment decontamination was effective.

At a minimum, equipment blank samples should be collected at a rate of 5 percent of the total samples planned for collection for each sampling technique used. This rate may be adjusted depending on the nature of the investigation (site inspection, remedial investigation, remedial site evaluation, long-term monitoring) and the associated project quality objectives (PQOs). Equipment blank samples will be analyzed for the same parameters as the samples collected with that particular equipment. If analytes pertinent to the project are found in the equipment blanks, the frequency of equipment blank samples may be increased after decontamination procedures have been modified to further evaluate the effectiveness of the decontamination procedure.

When disposable or dedicated sampling equipment is used, equipment blank samples do not need to be collected.

Sampling devices (e.g., gloved hands, dip nets, or traps) used for collection of tissue samples are generally non-intrusive into the organisms collected, so equipment blank samples will not be collected as long as the devices have been properly cleaned following Procedure I-F, *Equipment Decontamination*, and appear clean.

5.3 FIELD BLANKS

Field blanks, consisting of samples of the source water used as the final decontamination rinse water, will be collected on site by field personnel by pouring the source water into sample containers and then analyzed to assess whether contaminants may have been introduced during sample collection, storage, and transport.

The final decontamination rinse water source (the field blank source water) and equipment blank source water should all be from the same purified water source. Tap water used for steam cleaning augers or used in the initial decontamination buckets need not be collected and analyzed as a field blank since augers typically do not touch the actual samples and the final decontamination rinse water should be from a purified source.

Field blanks should be collected at a minimum frequency of one per sampling event per each source of water. A sampling event is considered to be from the time sampling personnel arrive at a site until they leave for more than a week. Field blanks will be analyzed for the same parameters as the samples collected during the period that the water sources are being used for decontamination. Additional field blanks may be required based on PQOs.

5.4 FIELD DUPLICATES

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

The interpretation of co-located duplicate data may be more complex than subsample duplicate data because of the number of variables associated with the results of this type of duplicate sample. Duplicate soil samples for VOC analysis shall always be co-located (i.e., not homogenized or otherwise processed or subsampled). Duplicates will be analyzed for the same analytical parameters as their associated original sample. Collection of both co-located and subsampled versions of the same sample may be performed to aid in approximating sampling and analysis error.

Field duplicates for biological tissue samples will consist of subsamples of the original sample. Twice the required volume of organisms for one sample will be collected and placed into one food-grade, self-sealing bag. The sample will later be homogenized in the laboratory and subsampled, producing an original and a duplicate sample. Tissue duplicate samples will be analyzed for the same analytical parameters as their associated original samples.

5.5 FIELD REPLICATES

Field replicates are completely separate incremental replicate samples (collected from a set of systematic random or stratified random locations within the DU that are different from those used for the primary incremental samples). A different random starting location is determined for each replicate collected in the selected DU. Field replicates are typically collected in sets of three (the primary sample and two replicate samples) to produce a triplicate.

Replicate sample increments are collected from the same sampling grid established through the DU for the primary incremental sample, though at different systematic random locations than initially used. The replicate increments should not be collected from the same points or co-located with those used for the primary incremental sample. Replicate samples are sent to the laboratory as “blind” samples, meaning the laboratory does not know they represent replicate samples of the primary incremental sample.

5.6 TEMPERATURE INDICATORS (BLANKS)

Temperature indicators (blanks) may be prepared in the lab or field by filling a small sample bottle or VOA vial with distilled water and sealing the container. One temperature indicator sample should be placed in each sample cooler or shipping container. Upon arrival at the laboratory, the temperature of the bottle is measured to determine if samples were adequately cooled during the shipment.

6. Records

Records of QC samples analyzed during ER Program CTO activities will be maintained on laboratory bench sheets, raw data sheets, in the laboratory computerized data system, and on QC summary forms, as requested. Analytical laboratories maintain records in accordance with their quality assurance manual (QAM) as part of performing environmental analytical work under DoD. Records shall be maintained in accordance with the analytical laboratory subcontract agreement specifications or the laboratory-specific QAM, whichever is more stringent.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-F, *Equipment Decontamination.*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

None.

Logbooks

1. Purpose

This standard operating procedure describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data records for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan Appendix A. Section 1.4 *Field Documentation SOPs* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the Contract Task Order (CTO) Manager and the Quality Assurance Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 DATA FORM

A data form is a predetermined format used for recording field data that may become, by reference, a part of the logbook (e.g., soil boring logs, trenching logs, surface soil sampling logs, groundwater sample logs, and well construction logs are data forms).

4. Responsibilities

The prime contractor CTO Manager or delegate is responsible for determining which team members shall record information in field logbooks and for obtaining and maintaining control of the required logbooks. The CTO Manager shall review the field logbook on at least a monthly basis. The CTO Manager or designee is responsible for reviewing logbook entries to determine compliance with this procedure and to ensure that the entries meet the project requirements.

A knowledgeable individual such as the Field Manager, CTO Manager, or quality control (QC) Supervisor shall perform a technical review of each logbook at a frequency commensurate with the level of activity (weekly is suggested, or, at a minimum, monthly). Document these reviews by the dated signature of the reviewer on the last page or page immediately following the material reviewed.

The Field Manager is responsible for ensuring that all project field staff follow these procedures and that the logbook is completed properly and daily. The Field Manager is also responsible for submitting copies to the CTO Manager, who is responsible for filing them and submitting a copy to the Navy (if required by the CTO Statement of Work).

The logbook user is responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. The logbook user is also responsible for safeguarding the logbook while having custody of it.

Field personnel are responsible for the implementation of this procedure.

All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedure

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Store the logbook in a clean location and use it only when outer gloves used for personal protective equipment (PPE) have been removed.

Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, include names of all samples collected in the logbook even if they are recorded elsewhere.

Enter field descriptions and observations into the logbook, as described in Attachment III-D-1, using indelible black ink.

Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all onsite activities and entries made in logbooks/forms
- Site name, and description
- Site location by longitude and latitude, if known
- Weather conditions, including estimated temperature and relative humidity
- Fieldwork documentation, including site entry and exit times
- Descriptions of, and rationale for, approved deviations from the work plan or field sampling plan
- Field instrumentation readings
- Names, job functions, and organizational affiliations of personnel on-site

- Photograph references
- Site sketches and diagrams made on-site
- Identification and description of sample morphology, collection locations and sample numbers as described in Procedure I-A-8, *Sample Naming*
- Sample collection information, including dates (month/day/year) and times (military) of sample collections, sample collection methods and devices, station location numbers, sample collection depths/heights, sample preservation information, sample pH (if applicable), analysis requested (analytical groups), etc., as well as chain-of-custody (COC) information such as sample identification numbers cross-referenced to COC sample numbers
- Sample naming convention
- Field QC sample information
- Site observations, field descriptions, equipment used, and field activities accomplished to reconstruct field operations
- Meeting information
- Important times and dates of telephone conversations, correspondence, or deliverables
- Field calculations
- PPE level
- Calibration records
- Contractor and subcontractor information (address, names of personnel, job functions, organizational affiliations, contract number, contract name, and work assignment number)
- Equipment decontamination procedures and effectiveness
- Laboratories receiving samples and shipping information, such as carrier, shipment time, number of sample containers shipped, and analyses requested
- User signatures

The logbook shall reference data maintained in other logs, forms, etc. Correct entry errors by drawing a single line through the incorrect entry, then initialing and dating this change. Enter an explanation for the correction if the correction is more than for a mistake.

At least at the end of each day, the person making the entry shall sign or initial each entry or group of entries.

Enter logbook page numbers on each page to facilitate identification of photocopies.

If a person's initials are used for identification, or if uncommon acronyms are used, identify these on a page at the beginning of the logbook.

At least weekly and preferably daily, the preparer shall photocopy (or scan) and retain the pages completed during that session for backup. This will prevent loss of a large amount of information if the logbook is lost.

6. Records

Retain the field logbook as a permanent project record. If a particular CTO requires submittal of photocopies of logbooks, perform this as required.

7. Health and Safety

Store the logbook in a clean location to keep it clean and use it only when outer gloves used for PPE have been removed.

8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Procedure I-A-8, *Sample Naming*.

9. Attachments

Attachment III-D-1: Description of Logbook Entries

Attachment III-D-1
Description of Logbook Entries

Logbook entries shall be consistent with Section A.1.4 *Field Documentation SOPs* of the UFP-QAPP Manual (DoD 2005) and contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously.

Name of Activity	For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing.
Task Team Members and Equipment	Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information.
Activity Location	Indicate location of sampling area as indicated in the field sampling plan.
Weather	Indicate general weather and precipitation conditions.
Level of PPE	Record the level of PPE (e.g., Level D).
Methods	Indicate method or procedure number employed for the activity.
Sample Numbers	Indicate the unique numbers associated with the physical samples. Identify QC samples.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Time and Date	Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year.
Analyses	Indicate the appropriate code for analyses to be performed on each sample, as specified in the WP.
Field Measurements	Indicate measurements and field instrument readings taken during the activity.
Chain of Custody and Distribution	Indicate chain-of-custody for each sample collected and indicate to whom the samples are transferred and the destination.
References	If appropriate, indicate references to other logs or forms, drawings, or photographs employed in the activity.
Narrative (including time and location)	Create a factual, chronological record of the team’s activities throughout the day including the time and location of each activity. Include descriptions of general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact the work schedule, request information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself. It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate.
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.
Checked by	Include the signature of the individual who performs the review of the completed entries.

Record Keeping, Sample Labeling, and Chain-Of-Custody

1. Purpose

The purpose of this standard operating procedure is to establish standard protocols for all United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific field personnel for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are used, and completing chain-of-custody/analytical request forms.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person responsible for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 CHAIN-OF-CUSTODY

Chain-of-custody (COC) is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

4. Responsibilities

The prime contractor CTO Manager is responsible for determining which team members shall record information in the field logbook and for checking sample logbooks and COC forms to ensure compliance with these procedures. The CTO Manager shall review COC forms on a monthly basis at a minimum.

The prime contractor CTO Manager and QA Manager or Technical Director are responsible for evaluating project compliance with the Project Procedures Manual. The QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Laboratory Project Manager or Sample Control Department Manager is responsible for reporting any sample documentation or COC problems to the CTO Manager or CTO Laboratory Coordinator within 24 hours of sample receipt.

The Field Manager is responsible for ensuring that all field personnel follow these procedures. The CTO Laboratory Coordinator is responsible for verifying that the COC/analytical request forms have been completed properly and match the sampling and analytical plan. The CTO Manager or CTO Laboratory Coordinator is responsible for notifying the laboratory, data managers, and data validators in writing if analytical request changes are required as a corrective action. These small changes are different from change orders, which involve changes to the scope of the subcontract with the laboratory and must be made in accordance with a respective contract (e.g., Comprehensive Long-Term Environmental Action Navy, remedial action contract).

NAVFAC Pacific ER Program field personnel are responsible for following these procedures while conducting sampling activities. Field personnel are responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedures

This procedure provides standards for documenting field activities, labeling the samples, documenting sample custody, and completing COC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

5.1 RECORD KEEPING

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct each day's events. Field logs such as soil boring logs and groundwater sampling logs will also be used. These procedures are described in Procedure III-D, *Logbooks*.

5.2 SAMPLE LABELING

Affix a sample label with adhesive backing to each individual sample container with the exception of pre-tared containers. Record the following information with a waterproof marker (ballpoint pen for containers for volatile analyses) on each label:

- Project name or number (optional)
- COC sample number
- Date and time of collection
- Sampler's initials
- Matrix (optional)
- Sample preservatives (if applicable)

- Analysis to be performed on sample (This shall be identified by the method number or name identified in the subcontract with the laboratory)
- Indicate if sample is to be used as the matrix spike (MS)/matrix spike duplicate (MSD) or laboratory triplicate sample

With the exception of sample containers with pre-tared labels, place clear tape over each label (preferably prior to sampling) to prevent the labels from tearing off, falling off, or being smeared, and to prevent loss of information on the label.

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

For volatile soil organic analyses (VOA), labels are not to be affixed to vials that are pre-tared by the laboratory. Instead, on each of the VOA vials in the sample set (typically three per sample), mark the sample COC Sample identification (ID) on the vial in ballpoint pen. Then wrap the vials together in bubble wrap and place one sample label on the bubble wrap and cover with tape. It is imperative that the COC Sample ID be clearly marked on each vial as this will help prevent laboratory error if the vials are inadvertently separated after removal from the bubble wrap.

5.3 CUSTODY PROCEDURES

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. Maintain custody of samples in accordance with the U.S. Environmental Protection Agency (EPA) COC guidelines prescribed in U.S. Environmental Protection Agency (EPA) *NEIC Policies and Procedures*, National Enforcement Investigations Center, Denver, Colorado, revised August 1991 (EPA 1978); EPA *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (TEGD), *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA OSWER Directive 9355 3-01) (EPA 1988, Appendix 2 of the *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports* (Cal/EPA 1988), and *Test Methods for Evaluating Solid Waste* (EPA 2007). A description of sample custody procedures is provided below.

5.3.1 Sample Collection Custody Procedures

According to the EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one’s actual physical possession or view
- It is in one’s physical possession and has not been tampered with (i.e., it is under lock or official seal)
- It is retained in a secured area with restricted access
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal

Place custody seals on sample containers (on bubble wrap for pre-tared containers) immediately after sample collection and on shipping coolers if the cooler is to be removed from the sampler's custody.

Place custody seals in such a manner that they must be broken to open the containers or coolers. Label the custody seals with the following information:

- Sampler's name or initials
- Date and time that the sample/cooler was sealed

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment III-E-1.

Field personnel shall also log individual samples onto COC forms (carbon copy or computer generated) when a sample is collected or just prior to shipping. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 5.4, indicating sample identification number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The samplers will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the person delivering the samples for transport will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the sampler and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, both parties shall sign and date the accompanying carbon copy COC forms, and the individual relinquishing the samples shall retain a copy of each form. One exception is when the samples are shipped; the delivery service personnel will not sign or receive a copy because they do not open the coolers. The laboratory shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment III-E-2.

5.3.2 Laboratory Custody Procedures

The following custody procedures are to be followed by an independent laboratory receiving samples for chemical analysis; the procedures in their Naval Facilities Engineering and Expeditionary Warfare Center-evaluated Laboratory Quality Assurance Plan must follow these same procedures. A designated sample custodian shall take custody of all samples upon their arrival at the analytical laboratory. The custodian shall inspect all sample labels and COC forms to ensure that the information is consistent, and that each is properly completed. The custodian will also measure the temperature of the temperature blank in the coolers upon arrival using either a National Institute for Standards and Technology calibrated thermometer or an infra-red temperature gun. The custodian shall note the condition of the samples including:

- If the samples show signs of damage or tampering
- If the containers are broken or leaking
- If headspace is present in sample vials
- Proper preservation of samples (made by pH measurement, except volatile organic compounds (VOCs) and purgeable total petroleum hydrocarbons (TPH) and temperature). The pH of VOC and purgeable TPH samples will be checked by the laboratory analyst after the sample aliquot has been removed from the vial for analysis.

- If any sample holding times have been exceeded

All of the above information shall be documented on a sample receipt sheet by the custodian.

Discrepancies or improper preservation shall be noted by the laboratory as an out-of-control event and shall be documented on an out-of-control form with corrective action taken. The out-of-control form shall be signed and dated by the sample control custodian and any other persons responsible for corrective action. An example of an out-of-control form is included as Attachment III-E-4.

The custodian shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4 degrees Celsius (soil samples for VOC analysis are to be stored in a frozen state until analysis). The unique laboratory number for each sample, the COC sample number, the client name, date and time received, analysis due date, and storage shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The custodian shall sign the shipping bill and maintain a copy.

Laboratory personnel shall be responsible for the care and custody of samples from the time of their receipt at the laboratory through their exhaustion or disposal. Samples should be logged in and out on internal laboratory COC forms each time they are removed from storage for extraction or analysis.

5.4 COMPLETING COC/ANALYTICAL REQUEST FORMS

COC form/analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment III-E-2 is an example of a generic COC/analytical request form that may be used by field personnel. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Attachment III-E-3 is an example of a completed site-specific COC/analytical request form, with box numbers identified and discussed in text below.

Box 1 *Project Manager:* This name shall be the name that will appear on the report. Do not write the name of the Project Coordinator or point of contact for the project instead of the CTO manager.

Project Name: Write the project name as it is to appear on the report.

Project Number: Write the project number as it is to appear on the report. It shall include the project number and task number. Also include the laboratory subcontract number.

Box 2 *Bill to:* List the name and address of the person/company to bill only if it is not in the subcontract with the laboratory.

Box 3 *Sample Disposal Instructions:* These instructions will be stated in the Master Service Agreement or each CTO statement of work with each laboratory.

Shipment Method: State the method of shipment (e.g., hand carry; air courier via FED EX, AIR BORNE, or DHL).

Comment: This area shall be used by the field team to communicate observations, potential hazards, or limitations that may have occurred in the field or additional information regarding analysis (e.g., a specific metals list, samples expected to contain high analyte concentrations).

Box 4 *Cooler Number:* This will be written on the inside or outside of the cooler and shall be included on the COC. Some laboratories attach this number to the trip blank identification, which helps track volatile organic analysis samples. If a number is not on the cooler, field personnel shall assign a number, write it on the cooler, and write it on the COC.

QC Level: Enter the reporting/QC requirements (e.g., Full Data Package, Summary Data Package).

Turn around time (TAT): TAT will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Once the SDG has been completed, standard TAT is 21 calendar days from receipt of the last sample in the SDG. Entering NORMAL or STANDARD in this field will be acceptable. If quicker TAT is required, it shall be in the subcontract with the laboratory and reiterated on each COC to remind the laboratory.

Box 5 *Type of containers:* Write the type of container used (e.g., 1 liter glass amber, for a given parameter in that column).

Preservatives: Field personnel must indicate on the COC the correct preservative used for the analysis requested. Indicate the pH of the sample (if tested) in case there are buffering conditions found in the sample matrix.

Box 6 *COC sample number:* This is typically a five-character alpha-numeric identifier used by the contractor to identify samples. The use of this identifier is important since the labs are restricted to the number of characters they are able to use. See Procedure I-A-8, *Sample Naming*.

Description (sample identification): This name will be determined by the location and description of the sample, as described in Procedure I-A-8, *Sample Naming*. This sample identification should not be submitted to the laboratory, but should be left blank. If a computer COC version is used, the sample identification can be input, but printed with this block black. A cross-referenced list of COC Sample Number and sample identification must be maintained separately.

Identify if sample requires laboratory subsampling.

Date Collected: Record the collection date to track the holding time of the sample. Note: For trip blanks, record the date it was placed in company with samples.

Time Collected: When collecting samples, record the time the sample is first collected. Use of the 24-hour military clock will avoid a.m. or p.m. designations (e.g., 1815 instead of 6:15 p.m.). Record local time; the laboratory is responsible for calculating holding times to local time.

Lab Identification: This is for laboratory use only.

Box 7 *Matrix and QC:* Identify the matrix (e.g., water, soil, air, tissue, fresh water sediment, marine sediment, or product). If a sample is expected to contain high analyte concentrations (e.g., a tank bottom sludge or distinct product layer), notify the laboratory in the comment section. Mark an "X" for the sample(s) that have extra volume for laboratory QC matrix spike/matrix spike duplicate (MS/MSD) or laboratory triplicate purposes. The sample provided for MS/MSD purposes is usually a field duplicate.

Box 8 *Analytical Parameters:* Enter the parameter by descriptor and the method number desired (e.g. benzene, toluene, ethylbenzene, and xylenes 8260B, polynuclear aromatic hydrocarbons 8270C, etc.). Whenever practicable, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

If the COC does not have a specific box for number of sample containers, use the boxes below the analytical parameter, to indicate the number of containers collected for each parameter.

Box 9 *Sampler's Signature:* The person who collected samples must sign here.

Relinquished By: The person who turned over the custody of the samples to a second party other than an express mail carrier, such as FEDEX, must sign here.

Received By: Typically, a representative of the receiving laboratory signs here. Or, a field crew member who delivered the samples in person from the field to the laboratory might sign here. A courier, such as Federal Express, does not sign here because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are to be sent to a subcontractor.

Relinquished By: In the case of subcontracting, the primary laboratory will sign the Relinquished By space and fill out an additional COC to accompany the samples being subcontracted.

Received By (Laboratory): This space is for the final destination (e.g., at a subcontracted laboratory).

Box 10 *Lab Number and Questions:* This box is to be filled in by the laboratory only.

Box 11 *Control Number:* This number is the “COC” followed by the first contractor identification number in that cooler, or contained on that COC. This control number must be unique (i.e., never used twice). Record the date the COC is completed. It should be the same date the samples are collected.

Box 12 *Total No. of Containers/row:* Sum the number of containers in that row.

Box 13 *Total No. of Containers/column:* Sum the number of containers in that column. Because COC forms contain different formats depending on who produced the form, not all of the information listed in items 1 to 13 may be recorded; however, as much of this information as possible shall be included.

COC forms tailored to each CTO can be drafted and printed onto multi-ply forms. This eliminates the need to rewrite the analytical methods column headers each time. It also eliminates the need to write the project manager, name, and number; QC Level; TAT; and the same general comments each time.

Complete one COC form per cooler. Whenever possible, place all volatile organic analyte vials into one cooler in order to reduce the number of trip blanks. Complete all sections and be sure to sign and date the COC form. One copy of the COC form must remain with the field personnel.

6. Records

The COC/analytical request form shall be faxed or e-mailed to the CTO Laboratory Coordinator for verification of accuracy. Following the completion of sampling activities, the sample logbook and COC forms will be transmitted to the CTO Manager for storage in project files. The data validators shall receive a copy also. The original COC/analytical request form shall be submitted by the laboratory along with the data delivered. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

7. Health and Safety

Not applicable.

8. References

California Environmental Protection Agency (Cal/EPA). 1988. *Technical Guidance Manual, Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports.* Solid Waste Disposal Program, Hydrogeology Section, Land Disposal Branch, Division of Water Quality, State Water Resources Control Board. August.

Department of Defense, United States (DoD). 2005a. Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure I-A-8, *Sample Naming.*

Procedure III-D, *Logbooks.*

9. Attachments

Attachment III-E-1, Chain-of-Custody Seal

Attachment III-E-2, Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3, Sample Completed Chain-of-Custody

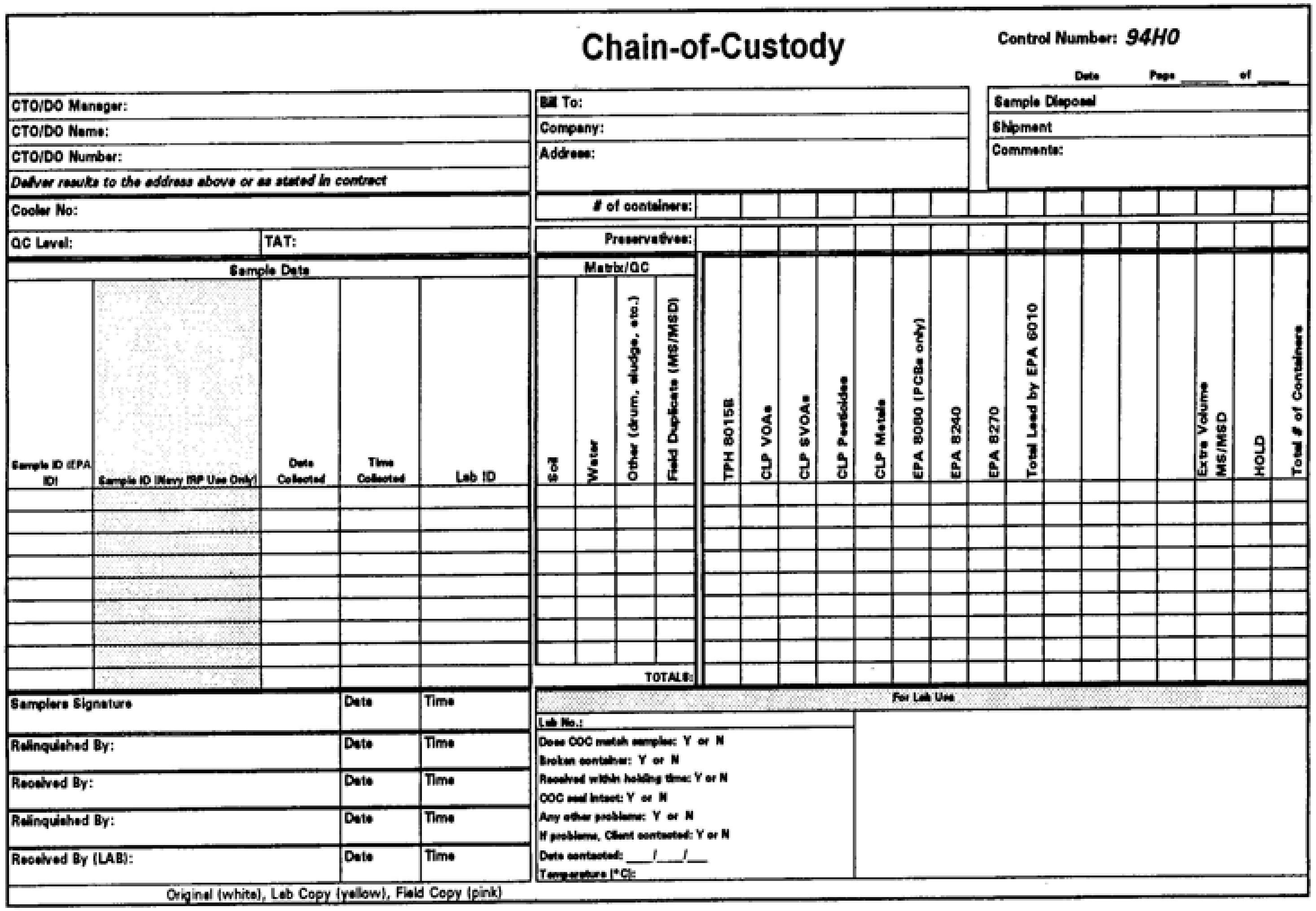
Attachment III-E-4, Sample Out-of-Control Form

Attachment III-E-1
Chain-of-Custody Seal

CHAIN-OF-CUSTODY SEAL

<table>
<tr><td colspan="2">CUSTODY SEAL</td></tr>
<tr><td colspan="2">Company Name (808) XXX-XXXX</td></tr>
<tr><td>Sampler’s Name/Initials:____________________</td><td>Date: _____________ Time: _____________</td></tr>
</table>

Attachment III-E-2
Generic Chain-of-Custody/Analytical Request Form



Chain-of-Custody

Control Number: 94H0

Date Page ____ of ____

CTO/DO Manager:
CTO/DO Name:
CTO/DO Number:
Deliver results to the address above or as stated in contract
Cooler No:
QC Level: TAT:

Bill To:
Company:
Address:

Sample Disposal
Shipment
Comments:

# of containers:
Preservatives:

Sample Data | Matrix/QC

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010					Extra Volume MS/MSD	HOLD	Total # of Containers
							TOTALS:																	

Samplers Signature	Date	Time
Relinquished By:	Date	Time
Received By:	Date	Time
Relinquished By:	Date	Time
Received By (LAB):	Date	Time

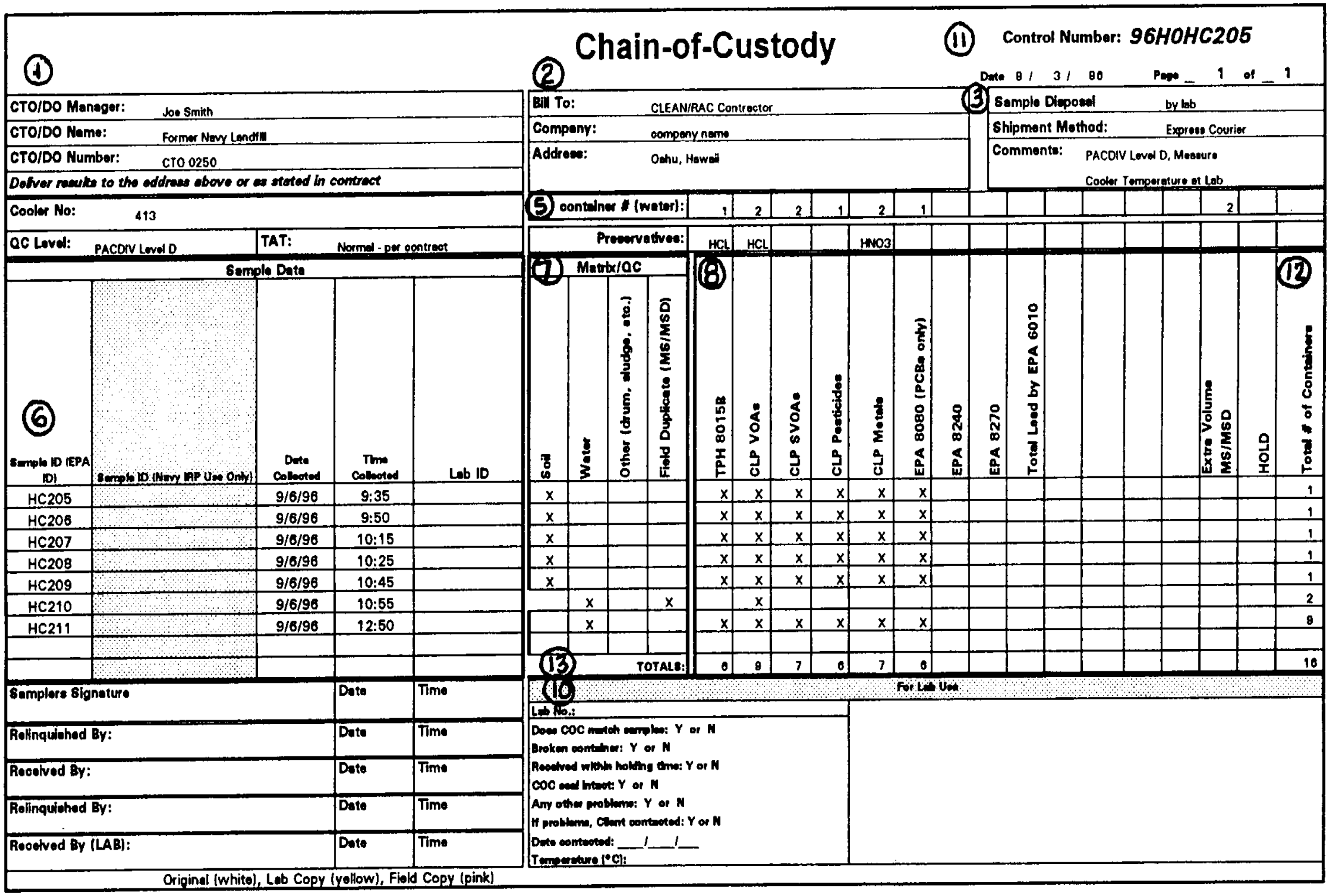
Original (white), Lab Copy (yellow), Field Copy (pink)

For Lab Use

Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3
Sample Completed Chain-of-Custody



Chain-of-Custody

⑪ Control Number: 96H0HC205

Date 9 / 3 / 96 Page 1 of 1

①
CTO/DO Manager: Joe Smith
CTO/DO Name: Former Navy Landfill
CTO/DO Number: CTO 0250
Deliver results to the address above or as stated in contract

②
Bill To: CLEAN/RAC Contractor
Company: company name
Address: Oahu, Hawaii

③
Sample Disposal by lab
Shipment Method: Express Courier
Comments: PACDIV Level D, Measure Cooler Temperature at Lab

④
Cooler No: 413
QC Level: PACDIV Level D
TAT: Normal - per contract

Sample Data ⑥					⑦ Matrix/QC				⑧															⑫
				⑤ container # (water):					1	2	2	1	2	1								2		
				Preservatives:					HCL	HCL			HNO3											
Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010					Extra Volume MS/MSD	HOLD	Total # of Containers
HC205		9/6/96	9:35		X				X	X	X	X	X	X										1
HC206		9/6/96	9:50		X				X	X	X	X	X	X										1
HC207		9/6/96	10:15		X				X	X	X	X	X	X										1
HC208		9/6/96	10:25		X				X	X	X	X	X	X										1
HC209		9/6/96	10:45		X				X	X	X	X	X	X										1
HC210		9/6/96	10:55			X		X		X														2
HC211		9/6/96	12:50			X			X	X	X	X	X	X										9
					⑬			TOTALS:	6	9	7	6	7	6										16

⑨

Samplers Signature	Date	Time
Relinquished By:	Date	Time
Received By:	Date	Time
Relinquished By:	Date	Time
Received By (LAB):	Date	Time

⑩ For Lab Use

Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

Sample Completed Chain-of-Custody

Attachment III-E-4
Sample Out-of-Control Form

OUT OF CONTROL FORM	Status	Date	Initial
	Noted OOC		
	Submit for CA*		
	Resubmit for CA*		
	Completed		

Date Recognized:		By:	
Dated Occurred:		Matrix	
Parameter (Test Code):		Method:	
Analyst:		Supervisor:	
1. Type of Event (Check all that apply)		2. Corrective Action (CA)* (Check all that apply)	
	Calibration Corr. Coefficient <0.995		Repeat calibration
	%RSD>20%		Made new standards
	Blank >MDL		Reran analysis
	Does not meet criteria:		Sample(s) redigested and rerun
	Spike		Sample(s) reextracted and rerun
	Duplicate		Recalculated
	LCS		Cleaned system
	Calibration Verification		Ran standard additions
	Standard Additions		Notified
	MS/MSD		Other (please explain)
	BS/BSD		
	Surrogate Recovery		
	Calculations Error		

Samples Affected (List by Accession AND Sample No.)

☐ Holding Times Missed	
☐ Other (Please explain	Comments:

3. Results of Corrective Action
☐ Return to Control (indicated with)
☐ Corrective Actions Not Successful - DATA IS TO BE FLAGGED with _____________.

Analyst:	Date:
Supervisor:	Date:
QA Department:	Date:

Sample Handling, Storage, and Shipping

1. Purpose

This standard operating procedure sets forth the methods for use by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel engaged in handling, storing, and transporting samples.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager and the Laboratory Project Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities are in compliance with this procedure.

The Field Manager is responsible for ensuring that all samples are shipped according to this procedure.

Field personnel are responsible for the implementation of this procedure.

The QA Manager or Technical Director is responsible for ensuring that sample handling, storage, and transport activities conducted during all CTOs are in compliance with this procedure.

All field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedures

5.1 HANDLING AND STORAGE

Immediately following collection, label all samples according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. In addition, when more than one volatile organic analyte

(VOA) vial is used to collect one sample, the chain-of-custody (COC) identification (ID) will be written on the VOA vials (even pre-tared vials) with a ball point pen for that sample. The lids of the containers shall not be sealed with duct tape, but should be covered with custody seals (except pre-tared containers which should have the custody seal placed on the outside of the protective bubble wrap). Wrap glass sample containers on the sides, tops, and bottoms with bubble wrap or other appropriate padding to prevent breakage during transport. When collecting three VOA vials per sample, it is acceptable to wrap all three vials together and store in one plastic bag. Store all glass containers for water samples in an upright position, never stacked or placed on their sides. Samples will be maintained as close to 4 degrees Celsius (°C) as possible from the time of collection through transport to the analytical laboratory, using refrigerators and/or freezers when appropriate. Place all containers into self-sealing bags and into an insulated cooler with wet ice while still in the field. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. Place an absorbent material (e.g., proper absorbent cloth material) on the bottom of the cooler to contain liquids in case of spillage. Ship samples as soon after collection as possible to allow the laboratory to meet holding times for analyses. Check with the laboratory for operating/sample receipt hours prior to all traditional and non-traditional holidays to ensure sample shipment will be received. When not shipping samples directly upon field collection, store samples in a refrigerator or freezer (never freeze water samples) until shipped to the laboratory.

5.2 PACKING

Each cooler must contain a temperature blank (small plastic bottle with sterile water) to confirm cooler temperature upon receipt at the laboratory. Water samples can be used as such, but it is best to include a designated temperature blank bottle, typically supplied by the laboratory with the coolers.

One trip blank must be included in each cooler containing samples for volatile analysis (e.g., volatile organic compounds, total petroleum hydrocarbons-gasoline range organics.

Cooler must be lined completely in ice at the bottom and all four sides. After confirming all project samples are accounted for and labeled correctly, place samples in cooler. Record sample IDs on cooler-specific COC(s). Pack glass containers for water samples in an upright position, never stacked or placed on their sides. Fill all empty space between sample containers with bubble wrap or other appropriate material (not Styrofoam). Place a layer of ice on top of samples and fill all empty space between ice and cooler lid with bubble wrap or other appropriate material.

Place laboratory copies of completed COC(s), and soil permit if applicable, into resealable bag and tape to underside of cooler lid.

5.3 SHIPPING

Follow all appropriate U.S. Department of Transportation regulations (e.g., 49 Code of Federal Regulations [CFR], Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized below.

5.3.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed to be hazardous unless enough evidence exists to indicate it is non-hazardous. If not suspected to be hazardous, shipments may be made as described in the Section 5.3.3 for non-hazardous materials. If hazardous, follow the procedures summarized below.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Perform hazardous materials identification by checking the list of dangerous goods for that particular mode of transportation. If not on that list, materials can be classified by checking the Hazardous Materials Table (49 CFR 172.102 including Appendix A) or by determining if the material meets the definition of any hazard class or division (49 CFR Part 173), as listed in Attachment III-F-2.

All persons shipping hazardous materials <u>must</u> be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials (49 CFR HM-126F Subpart H). The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. Carriers, such as commercial couriers, must also be trained. Modes of shipment include air, highway, rail, and water.

When shipping hazardous materials, including bulk chemicals or samples suspected of being hazardous, the proper shipping papers (49 CFR 172 Subpart C), package marking (49 CFR 172 Subpart D), labeling (49 CFR 172 Subpart E), placarding (49 CFR 172 Subpart F, generally for carriers), and packaging must be used. Attachment III-F-1 shows an example of proper package markings. Refer to a copy of 49 CFR each time hazardous materials/potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association Dangerous Goods Regulations publication, very small quantities of certain dangerous goods may be transported without certain marking and documentation requirements as described in 49 CFR Part 172. However, other labeling and packing requirements must still be followed. Attachment III-F-2 shows the volume or weight for different classes of substances. A "Dangerous Goods in Excepted Quantities" label must be completed and attached to the associated shipping cooler (Attachment III-F-3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment III-F-4, the Hazardous Materials Regulations do not apply to hydrochloric acid (HCl), nitric acid (HNO_3), sulfuric acid (H_2SO_4), and sodium hydroxide (NaOH) added to water samples if their pH or percentage by weight criteria are met. Hazardous Materials Regulations also do not apply to methanol (MeOH) for soil samples if the percentage by weight criterion is met. These samples may be shipped as non-hazardous materials as discussed below.

5.3.2 Non-hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

If preservatives (HCl, HNO_3, H_2SO_4, NaOH, or MeOH) are used, ensure their individual pH or percentage by weight criteria, as shown in item 4 of Attachment III-F-4, are met to continue shipping as non-hazardous samples.

When a cooler is ready for shipment to the laboratory, place the receiving laboratory address on the top of the cooler, place chain-of-custody seals on the coolers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, place soil permit labels on top if applicable, and seal the cooler with waterproof tape.

5.3.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the continental U.S. from locations outside the continental U.S. is controlled by the U.S. Department of Agriculture (USDA) and is subject to their inspection and regulation. A "USDA Soil Import Permit" is required to prove that the receiving analytical laboratory is certified by the USDA to receive and properly dispose of soil. In addition, all sample coolers must be inspected by a USDA representative, affixed with a label indicating that the coolers contain environmental samples, and accompanied by shipping forms stamped by the USDA inspector prior to shipment. In addition, the U.S. Customs Service must clear samples shipped from U.S. territorial possessions or foreign countries upon entry into the U.S. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs Service without the need to open coolers for inspection.

In Hawaii, soil sample shipments are typically brought to the courier at the airport where the courier contacts a USDA representative to make an inspection. Alternatively, the contractor may enter into an agreement with the USDA to ship soil samples. In this way, the USDA does not need to inspect each soil sample shipment. If the contractor maintains a Domestic Soil Permit, place the permit label and the soil origination label (Attachment III-F-9) on the top of the cooler. Place a copy of the receiving laboratory's soil permit with the COC inside the cooler. Confirm custody seals were placed on each container (Section 5.1) to ensure proper chain-of-custody control in the event coolers are opened for inspection.

In Guam, shipments can be dropped off directly to the Federal Express branch or to the courier at the airport. Alternatively, the courier can pick up shipments at each site provided that arrangements have been made regarding pickup time and location. USDA inspections occur outside of Guam. The laboratory's soil permit shall be placed with the COC inside the cooler, and the soil origination label (see Attachment III-F-9) should be placed on top of the cooler.

The USDA does not need to inspect water sample shipments.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need for the USDA and U.S. Customs Service to inspect the contents. Attachment III-F-5 shows an example of how paperwork may be placed on the outside of coolers for non-hazardous materials. For hazardous materials, refer to Section 5.3.1.

In summary, tape the paperwork listed below to the outside of the coolers to assist sample shipments. If a shipment is made up of multiple pieces (e.g., more than one cooler), the paperwork need only be attached to one cooler, provided that the courier agrees. All other coolers in the shipment need only be taped and have address and COC seals affixed.

1. **Courier Shipping Form & Commercial Invoice**. See Attachment III-F-6, and Attachment III-F-7 for examples of the information to be included on the commercial invoice for soil and water. Place the courier shipping form and commercial invoice inside a clear, plastic, adhesive-backed pouch that adheres to the package (typically supplied by the courier) and place it on the cooler lid as shown in Attachment III-F-5.
2. **Soil Import Permit (soil only)**. See Attachment III-F-8 and Attachment III-F-9 for examples of the soil import permit and soil samples restricted entry labels. The laboratory shall supply these documents prior to mobilization. The USDA in Hawaii often does stop

shipments of soil without these documents. Staple together the 2 inch × 2 inch USDA label (described below), and soil import permit, and place them inside a clear plastic pouch. The courier typically supplies the clear, plastic, adhesive-backed pouches that adhere to the package.

Placing one restricted entry label as shown in Attachment III-F-5 (covered with clear packing tape) and one stapled to the actual permit is suggested.

The USDA does not control water samples, so the requirements for soil listed above do not apply.

3. **Chain-of-Custody Seals**. The laboratory should supply the seals. CTO personnel must sign and date these. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. Placing the seals over the tape (as shown in Attachment III-F-5), then covering it with clear packing tape is suggested. This prevents the seal from coming loose and enables detection of tampering.
4. **Address Label**. Affix a label stating the destination (laboratory address) of each cooler.
5. **Special Requirements for Hazardous Materials**. See Section 5.3.1.

Upon receipt of sample coolers at the laboratory, the sample custodian shall inspect the sample containers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. The samples shall then be either immediately extracted and/or analyzed, or stored in a refrigerated storage area until they are removed for extraction and/or analysis. Whenever the samples are not being extracted or analyzed, they shall be returned to refrigerated storage.

6. Records

Maintain records as required by implementing these procedures.

7. Health and Safety

Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2012) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories*. Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

Attachment III-F-1: Example Hazardous Materials Package Marking

Attachment III-F-2: Packing Groups

Attachment III-F-3: Label for Dangerous Goods in Excepted Quantities

Attachment III-F-4: SW-846 Preservative Exception

Attachment III-F-5: Non-Hazardous Material Cooler Marking Figure for Shipment From Outside The Continental United States

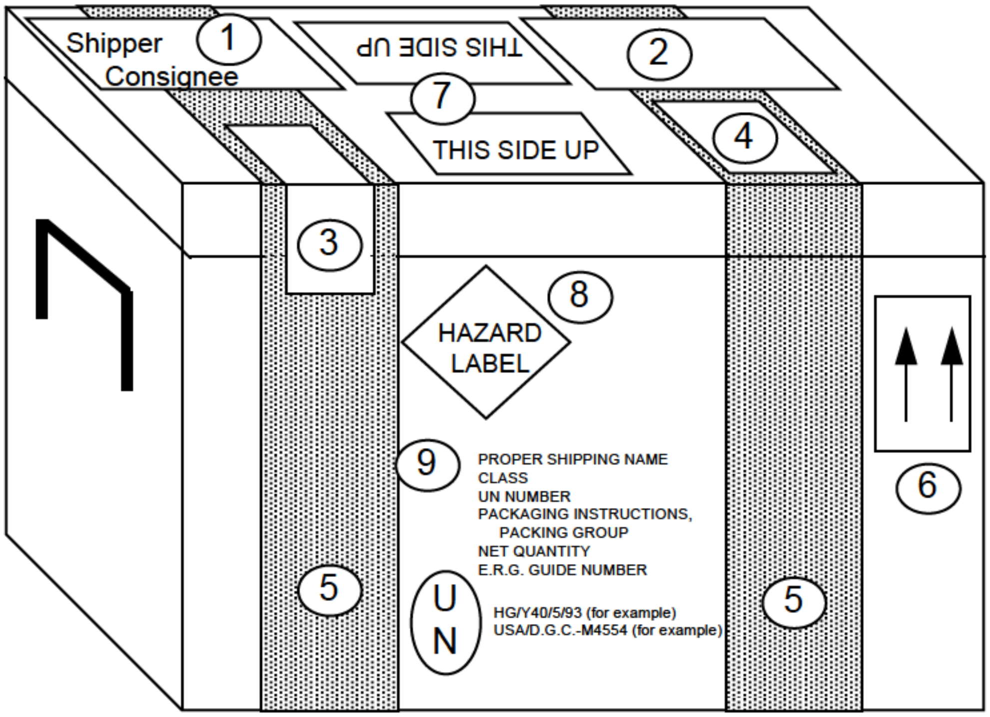
Attachment III-F-6: Commercial Invoice – Soil

Attachment III-F-7: Commercial Invoice – Water

Attachment III-F-8: Soil Import Permit

Attachment III-F-9: Soil Samples Restricted Entry Labels

Attachment III-F-1
Example Hazardous Material Package Marking



① **AIR BILL/COMMERCIAL INVOICE**
② **USDA PERMIT (Letter to Laboratory from USDA)**
③ **CUSTODY SEAL**
④ **USDA 2" X 2" SOIL IMPORT PERMIT**
⑤ **WATERPROOF STRAPPING TAPE**
⑥ **DIRECTION ARROWS STICKER - TWO REQUIRED**
⑦ **THIS SIDE UP STICKERS**
⑧ **HAZARD LABEL**
⑨ **HAZARDOUS MATERIAL INFORMATION**
⑩ **PACKAGE SPECIFICATIONS**

Attachment III-F-2
Packing Groups

PACKING GROUP OF THE SUBSTANCE	**PACKING GROUP 1**		**PACKING GROUP II**		**PACKING GROUP III**	
CLASS or DIVISION of PRIMARY or SUBSIDIARY RISK	Packagings		Packagings		Packagings	
	Inner	Outer	Inner	Outer	Inner	Outer
1: Explosives	---------------------------- Forbidden (Note A) ----------------------------------					
2.1: Flammable Gas	---------------------------- Forbidden (Note B) ----------------------------------					
2.2: Non-Flammable, non-toxic gas	---------------------------- See Notes A and B ----------------------------------					
2.3: Toxic gas	---------------------------- Forbidden (Note A) ----------------------------------					
3. Flammable liquid	30 mL	300 mL	30 mL	500 mL	30 mL	1 L
4.1 Self-reactive substances	Forbidden		Forbidden		Forbidden	
4.1: Other flammable solids	Forbidden		30 g	500 g	30 g	1 kg
4.2: Pyrophoric substances	Forbidden		Not Applicable		Not Applicable	
4.2 Spontaneously combustible substances	Not Applicable		30 g	500 g	30 g	1 kg
4.3: Water reactive substances	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.1: Oxidizers	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.2: Organic peroxides (Note C)	See Note A		30 g or 30 mL	500 g or 250 mL	Not Applicable	
6.1: Poisons - Inhalation toxicity	Forbidden		1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - oral toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - dermal toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.2: Infectious substances	---------------------------- Forbidden (Note A) ----------------------------------					
7: Radioactive material (Note D)	---------------------------- Forbidden (Note A) ----------------------------------					
8: Corrosive materials	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
9: Magnetized materials	---------------------------- Forbidden (Note A) ----------------------------------					
9: Other miscellaneous materials (Note E)	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L

Note A: *Packing groups are not used for this class or division.*
Note B: *For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.*
Note C: *Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.*
Note D: *See 6.1.4.1, 6.1.4.2 and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.*
Note E: *For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.*

Attachment III-F-3
Label for Dangerous Goods in Excepted Quantities

Attachment III-F-4
SW-846 Preservative Exception

Measurement	Vol. Req. (mL)	Container[2]	Preservative [3,4]	Holding Time[5]
MBAS	250	P,G	Cool, 4ºC	48 Hours
NTA	50	P,G	Cool, 4ºC	24 Hours

1. More specific instructions for preservation and sampling are found with each procedure as detailed in this manual. A general discussion on sampling water and industrial wastewater may be found in ASTM, Part 31, p. 72-82 (1976) Method D-3370.

2. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing and sample splitting is completed.

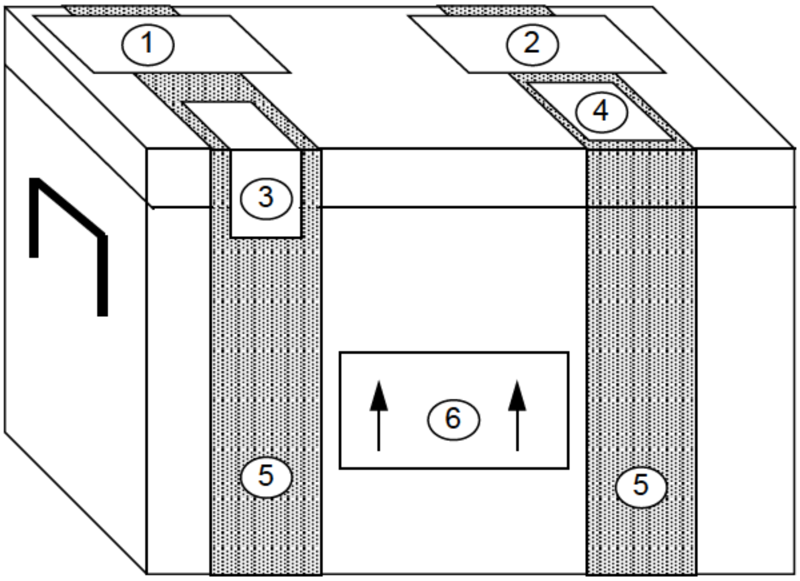
4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

Attachment III-F-5

Non-Hazardous Material Cooler Marking Figure for Shipment from outside the Continental United States



① **AIR BILL/COMMERCIAL INVOICE**
② **USDA PERMIT (Letter to Laboratory from USDA)**
③ **CUSTODY SEAL**
④ **USDA 2" X 2" SOIL IMPORT PERMIT**
⑤ **WATERPROOF STRAPPING TAPE**
⑥ **DIRECTION ARROWS STICKER - TWO REQUIRED**

Attachment III-F-6
Commercial Invoice – Soil

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Receipt <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL
AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Soil samples for labora analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title	Signature	Date
Joe Smith, Ogden	Joe Smith	1/1/94

Attachment III-F-7
Commercial Invoice – Water

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Rece <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Water samples for labo analysis only				$1.00	$3.00

TOTAL NO. OF PKGS.	TOTAL WEIGHT	TOTAL INVOICE VALUE
3		$3.00

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

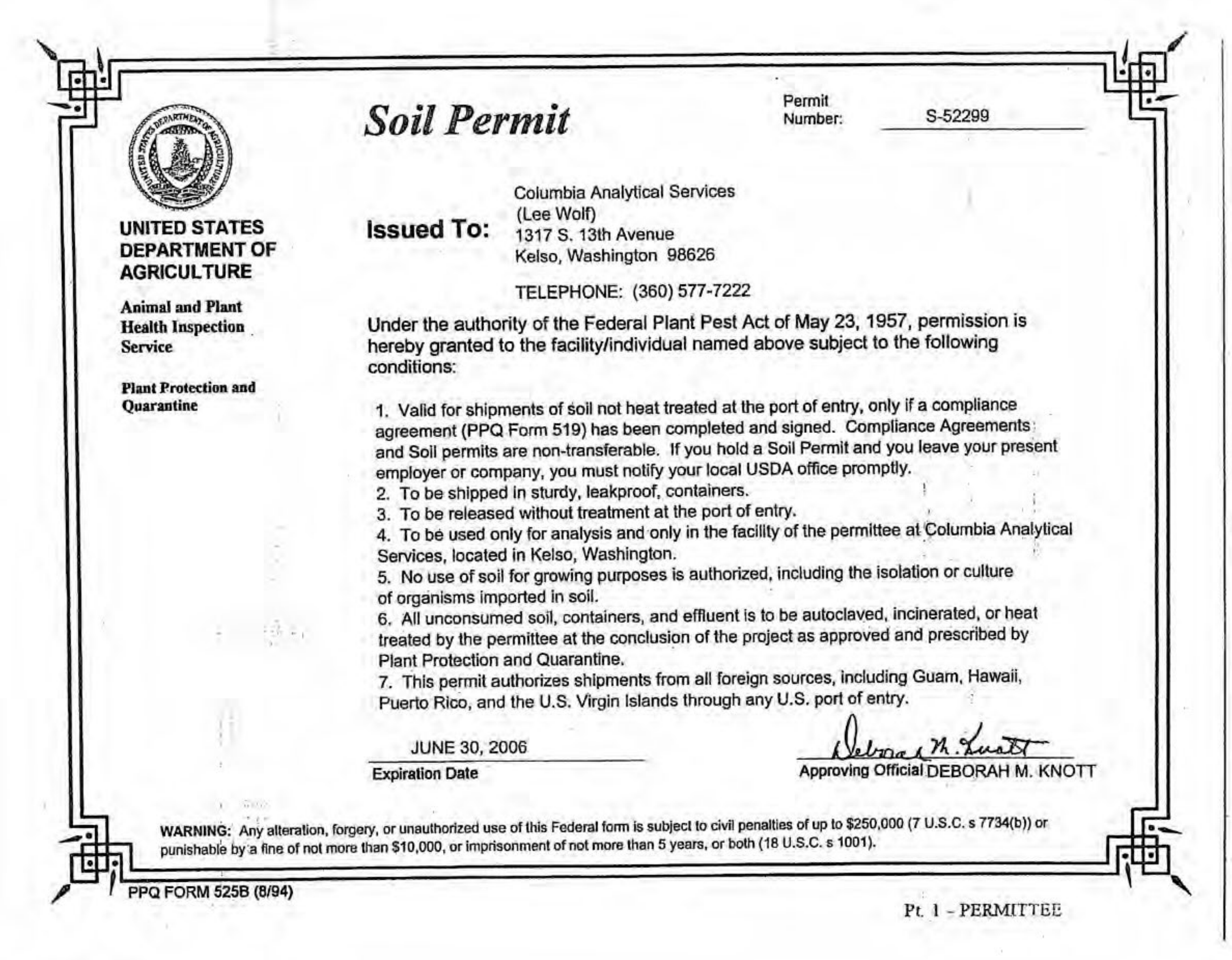
DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title	Signature	Date
Joe Smith, Ogden	Joe Smith	1/1/94

Attachment III-F-8
Soil Import Permit



UNITED STATES DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Soil Permit

Permit Number: S-52299

Issued To:
Columbia Analytical Services
(Lee Wolf)
1317 S. 13th Avenue
Kelso, Washington 98626

TELEPHONE: (360) 577-7222

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed. Compliance Agreements and Soil permits are non-transferable. If you hold a Soil Permit and you leave your present employer or company, you must notify your local USDA office promptly.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Columbia Analytical Services, located in Kelso, Washington.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry.

JUNE 30, 2006
Expiration Date

Debra M. Knott
Approving Official DEBORAH M. KNOTT

WARNING: Any alteration, forgery, or unauthorized use of this Federal form is subject to civil penalties of up to $250,000 (7 U.S.C. s 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. s 1001).

PPQ FORM 525B (8/94)

Pt. 1 - PERMITTEE

Attachment III-F-9

Soil Samples Restricted Entry Label and Soil Origin Label

U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

PLANT PROTECTION AND QUARANTINE

HYATTSVILLE, MARYLAND 20782

SOIL SAMPLES

RESTRICTED ENTRY

The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550 *Edition of 12/77 may be used*

(JAN 83)

Soil Samples Restricted Entry Label

SOIL ENCLOSED

Origin of Soil ________________________

Soil Origin Label

DEPARTMENT OF DEFENSE UNITED STATES OF AMERICA

DEPARTMENT OF THE NAVY
JOINT BASE PEARL HARBOR-HICKAM
850 TICONDEROGA ST STE 100
PEARL HARBOR HI 96860-5102

11000
JB00/Ser 818
29 Oct 18

From: Commander, Joint Base Pearl Harbor-Hickam

Subj: JOINT BASE PEARL HARBOR-HICKAM GREENWASTE POLICY

Encl: (1) Map for Greenwaste Disposal

1. All greenwaste cleared or generated on any Joint Base Pearl Harbor-Hickam (JBPHH) property (to include all outlying annexes and properties) must remain on JBPHH property. Follow below specifications regarding drop-off site as well as whether or not greenwaste can be chipped or left whole. Greenwaste generated on JBPHH cannot be taken to other non-JBPHH work site(s). Additionally, no inter-mixing of greenwaste from any non-JBPHH source is allowed. If any life stage of Coconut Rhinoceros Beetle (CRB) or suspected CRB is found, stop greenwaste clearing and call Hawaii Department of Agriculture Pest Hotline at 808-643-PEST (7378).

2. Zones for Whole vs. Chipped Greenwaste - Enclosure (1).

a. ■ WHOLE (includes Hickam, Pearl Harbor Waterfront and Shipyard, Navy Marine Golf Course, Navy Makalapa area, Navy Moanalua area, McGrew Point and Ford Island). All greenwaste generated in this zone must be kept whole and delivered within 24 hours to the Fire Training Area (FTA). See FTA location on map. During 24-hour period, material must be contained using an approved cover/tarp. No stockpiling/staging of any form of greenwaste allowed. No chipping in this zone allowed. Once cleared, no form of greenwaste can be left on the ground. Following is stump grinding protocol. All trees (to include palms) should be cut in 3-feet sections with fronds/small branches left whole. Oversized trunks may need a waiver.

b. ▨ CHIP (includes: Pearl City Peninsula, Waipio Peninsula, West Loch, Lualualei, Barber's Point Golf Course/Kalaeloa and NCTAMS/Wahiawa Annex). All greenwaste generated in this zone must be chipped and transported to the Bio-Solid Treatment Facility (BTF) within 24 hours. See map for BTF location. If 24-hour period includes overnight, material must stay on JBPHH and in a fully enclosed container/vehicle with immediate next-day delivery to BTF. During transport to BTF, if vehicle is not fully enclosed, vehicle must use an approved cover/tarp to cover an open top/back truck bed during transport. No stockpiling or staging of any form of greenwaste is allowed. Once cleared, no form of greenwaste can be left on the ground. Stump grinding protocol is defined below.

3. Waivers to Policy.

a. Any waiver to the above policy must be approved via waiver application point of contact. Waivers may be granted that allow for changes to the form of greenwaste, i.e., chipped versus whole or to the specific drop-off location that can be used. No JBPHH greenwaste can go to off-site treatment facilities (HECO and/or Hawaiian Earth Products) unless advanced approval is granted via waiver application.

b. If no waiver is granted, then above guidelines must be followed.

4. Stump grinding: All stump grinding on JBPHH (including all outlying properties and annexes) shall follow contract specific guidance in addition to grind stump 12-18 inches down. Ground material will be delivered to an approved composting facility within 24 hours. Stump hole will be filled with topsoil and covered with sod.

Scott R. King
S. R. KING
By direction

FOR INQUIRIES REGARDING GREENWASTE POLICY/WAIVER APPLICATION, CONTACT:

CORRINA CARNES (808) 722-7285 OR CORRINA.CARNES@NAVY.MIL

FIRE TRAINING AREA (FTA) AND BIO-SOLID TREATMENT FACILITY (BTF) CONTACTS:

LONNIE FELISE (808) 347-2645 OR ED DUMLAO (808)-347-2639

LONNIE.FELISE@NAVY.MIL EDWIN.DUMLAO@NAVY.MIL

NOTE: BTF CAN RECEIVE NON-NAVY DOD CHIPPED GREENWASTE ON A CASE BY CASE BASIS. CONTACT BTF POC FOR APPROVAL

★ BTF

BIO-SOLID TREATMENT FACILITY @ BARBER'S POINT

2187 LAKE CHAMPLAIN ST.

KAPOLEI, HI 96707

★ FTA

FIRE TRAINING AREA @ HICKAM

WORCHESTER DRIVE

(ACROSS STREET FROM MAMALA BAY

GOLF COURSE)

Enclosure (1)

Appendix B:
Accident Prevention Plan
(Provided under Separate Cover)

Appendix C:
Analytical Data Package Requirements

GC/MS "Full" Deliverables

Item #	Deliverable
1	Chain of Custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of instrument blanks - metals only (listing or link with associated samples)
7	Summary of surrogate recoveries
8	Summary of initial calibration data (RRF and %RSD, or r if applicable)
9	Summary of continuing calibration (%D and RRF)
10	Summary of internal standards (area response and retention time)
11	Summary of instrument tuning (listing or link with associated samples, must show 12 hour clock)
12	Injection logs
13	Extraction/preparation logs
14	Case narrative to discuss anomalies
15	Raw data associated with the summary forms listed above
16	Raw data for item #2 which includes chromatograms, log books, quantitation reports, and spectra

Note: The data deliverable package must have a table of contents and be paginated.

GC "Full" Deliverables

Item #	Deliverable
1	Chain of Custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of surrogate recoveries
7	Summary of initial calibration data (RF and %RSD, r if applicable)
8	Summary of continuing calibration (%D)
9	Injection logs
10	Extraction/preparation logs
11	Case narrative to discuss anomalies
12	Raw data associated with the summary forms listed above
13	Raw data for item #2 which includes chromatograms, log books, quantitation reports, and spectra

Note: The data deliverable package must have a table of contents and be paginated.

Trace Metals "Full" Deliverables

Item #	Deliverable
1	Chain of Custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of instrument blanks (listing or link with associated samples)
7	Summary of initial calibration data (% recovery - ICP) or (correlation coefficient, r - GFAA)
8	Summary of continuing calibration (%D or % recovery)
9	Injection logs
10	Extraction/preparation logs
11	Summary of ICP interference check (listing or link with associated samples)
12	Summary of graphite furnace AA, ICP post digestion spike, and serial dilution results
13	Summary of graphite furnace AA standard addition results (as required)
14	Case narrative to discuss anomalies
15	Raw data associated with the summary forms listed above
16	Raw data for item #2 which includes log books, quantitation reports, and spectra

Note: The data deliverable package must contain a table of contents and be paginated.

General Chemistry "Full" Deliverables

Item #	Deliverable
1	Chain of custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of initial calibration data (correlation coefficient, r)
7	Summary of continuing calibration (%D or % recovery), if applicable
8	Injection logs
9	Extraction/preparation logs, if applicable
10	Case narrative to discuss anomalies
11	Raw data associated with the summary forms listed above
12	Raw data for item #2, which includes log books, quantitation reports, and spectra

Note: The data deliverable package must contain a table of contents and be paginated.

Miscellaneous Analysis Deliverables

Item #	Deliverable
1	Chain of Custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of duplicate recoveries and control limits (listing or link with associated samples)
4	Method blanks (listing or link with associated samples)
5	Extraction/preparation logs
6	Case narrative to discuss anomalies
7	Raw data associated with the summary forms listed above
8	Raw data for item #2 which includes log books

Note: The data deliverable package must contain a table of contents and be paginated.

EQuIS Electronic Data Deliverable (EDD) File Specifications

1.1 EDD FORMAT DESCRIPTION

The EQuIS EDD consists of four of five tables in the EQuIS electronic data processer (EDP) AECOM EDD format. These tables are the field sample table (FSample), the laboratory sample table (LabSMP), the laboratory test table (LabTST), the laboratory results table (LabRES), and the laboratory batch table (LabBCH). Each EDD will comprise four files to describe samples, tests, results, and batches. The EDD format allows for two different tables to describe samples, the field sample table (FSample) and the laboratory sample table (LabSMP). Only one of these two tables will be included with the EDD. Which sample description table will be included will be communicated by the AECOM project chemist or data manager during project setup.

The attached tables provide documentation of the structure and contents of each of the EDD tables. The field sample table is described in Table 1, the laboratory sample table is described in Table 2, the laboratory test table is described in Table 3, the laboratory results table is described in Table 4, and the laboratory batch table is described in Table 5. Documentation of the structure and content of the EDD is also provided directly by the EQuIS Data Processor (EDP). Click the "EDD Description" button in the "Tools" section of the "Home" ribbon section of EDP. The AECOM EDD format file and EDP software are available from http://www.earthsoft.com/products/edp/edp-format-for-aecom.

1.2 EDD SUBMITTAL

The EDD file can be in one of the following formats:

- ZIP archive of tab-delimited text files (.txt)
- spreadsheet (.xls or .xlsx)
- database (.mdb)

EDD Packages must be named using a specific naming convention as described below:

EDD File Name:

<Unique ID>.<Facility Code>.{zip | xls | xlsx | mdb}

ZIP archive text file EDD section names:

<Unique ID>.<EDD Section Name>.txt

***Or* XLS worksheet *or* MDB table EDD section names:**

<EDD Section Name>

Where:

<Unique ID> = A unique identifier which will be the Sample Delivery Group name unless other arrangements have been made.

<Facility Code> = The facility code for the facility to which this EDD will be loaded, will be communicated by the AECOM project chemist or data manager at project setup.

<EDD Section Name> = The name of the section within the EDD (i.e. LabSMP or FSample, LabTST, LabRES, LabBCH) as it appears in EDP.

Between each of the name elements is a "." (period). It is very important that it is a period and not a "-" (dash), "_" (underscore), or any other character.

For example, the EDD file name for a laboratory reporting a batch identified as SDG001 and where the facility code is TEST_FAC_CODE, a ZIP archive of text files would be named "SDG001.TEST_FAC_COD.zip" and contain the following files:

SDG001.FSample.txt
SDG001.LabTST.txt
SDG001.LabRES.txt
SDG001.LabBCH.txt

1.3 EDD RESUBMITTAL

EDD packages may be resubmitted. However, in order to resubmit corrected EDDs, the files must each be renamed, regardless of the reason(s) for resubmittal.

For Example, a lab originally submits an EDD Package (.zip) file named "SDG001.TEST_FAC_COD.zip" which contains an EDD named "SDG001.FSample.txt". If the lab later makes a change to one of the EDDs, it would have to submit a new EDD Package named "SDG001R.TEST_FAC_COD.zip" with the EDD named "SDG001R.FSample.txt".

1.4 EDD REFERENCE VALUES

A reference values file should be delivered from the AECOM project chemist or data manager to the data provider at project setup. No EDDs will be accepted that do not strictly adhere to the project-specific reference values. If new values need to be used, they must be identified and explained to the AECOM project chemist or data manager who will provide approval or alternate codes to use before any EDD should be submitted.

1.5 EDD DETECTION LIMIT REPORTING REQUIREMENTS

For work done in accordance with the DoD Quality Systems Manual, detection limit values will be reported in the following fields in the LabRES section of the EDD:

- quantitation_limit = LOQ
- reporting_detection_limit = LOD
- method_detection_limit = DL

Table 1: Field descriptions for the AECOM Field Sample Table (FSample)

Field Name	Data Type[a]	Key	Required	Default	Parent	Lookup Table and Field	Field Name Description
sys_sample_code	Text(40)	PK	Y				Unique sample identifier. Each sample must have a unique value, including spikes and duplicates. Laboratory QC samples must also have unique identifiers. Sample IDs for field samples must be reported exactly as found on the chain of custody form, and may not be changed for subsequent tests (dilution, re-analysis, leachate, etc.)
sample_name	Text(50)						Additional sample identification information as necessary. Is not required to be unique (i.e., duplicates are OK).
sample_matrix_code	Text(10)		Y			rt_matrix.matrix_code	Code which distinguishes between different type of sample matrix. For example, soil samples must be distinguished from ground water samples, etc. The matrix of the sample as analyzed may be different from the matrix of the sample as retrieved (e.g. leachates), so this field is required at both the sample and test level. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
sample_type_code	Text(10)		Y			rt_sample_type.sample_type_code	Code which distinguishes between different types of samples. For example, normal field samples must be distinguished from laboratory method blank samples, etc. I Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
sample_source	Text(10)		Y	Field		(Enumeration: Field or Lab)	"Field" for field samples or "Lab" for internally generated lab QC samples No other values are allowed.
parent_sample_code	Text(40)				AECOMFSample.sys_sample_code		The value of "sys_sample_code" that uniquely identifies the sample that was the source of this sample. For example, the value of this field for a duplicate sample would identify the normal sample of which this sample is a duplicate. Required in the laboratory EDD for all laboratory "clone" samples (e.g., spikes and duplicates). Must be blank for samples which have no parent (e.g., normal field samples, LCS samples, method blanks, etc.).
sample_delivery_group	Text(20)						Sample delivery group as defined by AECOM project manager. Required for all field samples, optional for samples originating in the laboratory.
sample_date	Date						Date sample was collected in the field or sample was originated in the lab. Date information must be identical with the date from the chain of custody form.
sample_time	Time						Time sample was collected in the field or sample was originated in the lab. Time information must be identical with the date from the chain of custody form.
sys_loc_code	Text(20)						Sample collection location.
start_depth	Numeric						Beginning depth (top) of soil sample. This is an optional field for the laboratory EDD unless otherwise specified by the AECOM project manager.
end_depth	Numeric						Ending depth (bottom) of soil sample. This is an optional field for the laboratory EDD unless otherwise specified by the AECOM project manager.
depth_unit	Text(15)					rt_unit.unit_code	Unit of measurement for the sample begin and end depths. This is an optional field for the laboratory EDD unless otherwise specified by the AECOM project manager. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
chain_of_custody	Text(40)						Chain of custody identifier. A single sample may be assigned to only one chain of custody. This is an optional field for laboratory EDD unless otherwise specified by the AECOM project manager.

Field Name	Data Type [a]	Key	Required	Default	Parent	Lookup Table and Field	Field Name Description
sent_to_lab_date	Date						Date sample was sent to lab (in MM/DD/YY format for EDD).
sample_receipt_date	Date						Date that sample was received at laboratory (in MM/DD/YY format for EDD).
sampler	Text(50)						Name or initials of sampler.
sampling_company_code	Text(20)						Name or initials of sampling company (no controlled vocabulary).
sampling_reason	Text(30)						Optional reason for sampling. No controlled vocabulary is enforced.
sampling_technique	Text(40)					rt_sample_method.method_code	Sampling technique. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
task_code	Text(40)						Code used to identify the task under which the field sample was retrieved. This is an optional field for laboratory EDD unless otherwise specified by the Chem project manager.
collection_quarter	Text(6)						Quarter of the year sample was collected (e.g., "1Q96").
composite_yn	Text(1)					(Enumeration: Y or N)	Used to indicate whether a sample is a composite sample. "Y" for composite, "N" for not composite.
composite_desc	Text(255)						Description of composite sample (if composite_yn is "Y").
sample_class	Text(10)						Sample class code. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
custom_field_1	Text(255)						Custom sample field.
custom_field_2	Text(255)						Custom sample field.
custom_field_3	Text(255)						Custom sample field.
comment	Text(255)						Sample comments as necessary (optional).

Red lettered field names are required

Red lettered and underlined field names are required and lookups

Blue lettered field names are lookups

[a] For text data type, the number of allowable characters is listed in parentheses.

PK Primary Key

Table 2: Field descriptions for the AECOM Laboratory Sample Table (LabSMP)

Field Name	Data Type[a]	Key	Required	Default	Parent	Lookup Table and Field	Comment
sys_sample_code	Text(40)	PK	Y				Unique sample identifier. Each sample must have a unique value, including spikes and duplicates. Laboratory QC samples must also have unique identifiers. Sample IDs for field samples must be reported exactly as found on the chain of custody form, and may not be changed for subsequent tests (dilution, re-analysis, leachate, etc.)
sample_type_code	Text(20)		Y			rt_sample_type.sample_type_code	Code which distinguishes between different types of samples. For example, normal field samples must be distinguished from laboratory method blank samples, etc. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
sample_matrix_code	Text(10)		Y			rt_matrix.matrix_code	Code which distinguishes between different type of sample matrix. For example, soil samples must be distinguished from ground water samples, etc. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD. The matrix of the sample as analyzed may be different from the matrix of the sample as retrieved (e.g. leachates), so this field is required at both the sample and test level.
sample_source	Text(10)		Y	Lab		(Enumeration: Field or Lab)	"Field" for field samples or "Lab" for internally generated lab QC samples. No other values are allowed.
parent_sample_code	Text(40)				AECOMLabSMP.sys_sample_code		The value of "sys_sample_code" that uniquely identifies the sample that was the source of this sample. For example, the value of this field for a duplicate sample would identify the normal sample of which this sample is a duplicate. Required in the laboratory EDD for all laboratory "clone" samples (e.g., spikes and duplicates). Field duplicates may be submitted blind to the laboratory, so this field is not required in the laboratory EDD for field "clones". Must be blank for samples which have no parent (e.g., normal field samples, LCS samples, method blanks, etc.).
comment	Text(255)						Sample comments as necessary (optional).
sample_date	Date						Date sample was collected in the field or sample was originated in the lab. Date information must be identical with the date from the chain of custody form.
sample_time	Time						Time sample was collected in the field or sample was originated in the lab. Time information must be identical with the date from the chain of custody form.
sample_receipt_date	Date						Date that field sample was received at laboratory (in MM/DD/YY format for EDD).
sample_delivery_group	Text(20)						Sample delivery group as defined by AECOM project manager. Required for all field samples, optional for samples originating in the laboratory
standard_solution_source	Text(20)						Relevant only for lab-generated samples. Description of the source of standard solutions for certain laboratory samples (e.g., LCS).
sample_receipt_time	Time						Time of lab receipt sample in 24-hr (military) HH:MM format.

Red lettered field names are required
Red lettered and underlined field names are required and lookups
Blue lettered field names are lookups
[a] For text data type, the number of allowable characters is listed in parentheses.
PK Primary Key

Table 3: Field descriptions for the AECOM Laboratory Test Table (LabTST)

Field Name	Data Type [a]	Key	Required	Default	Parent	Lookup Table and Field	Comment
sys_sample_code	Text(40)	PK	Y		AECOMFSample.sys_sample_code AECOMLabSMP.sys_sample_code		Unique sample identifier. Each sample must have a unique value, including spikes and duplicates. Laboratory QC samples must also have unique identifiers. Sample IDs for field samples must be reported exactly as found on the chain of custody form, and may not be changed for subsequent tests (dilution, re-analysis, leachate, etc.)
lab_anl_method_name	Text(20)	PK	Y			rt_analytic_method.analytic_method	Laboratory analytic method name or description. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD. The method name should be sufficient to reflect operation of the laboratory.
analysis_date	Date	PK	Y				Date of sample analysis in MM/DD/YY format. May refer to either beginning or end of the analysis as required by AECOM project manager.
analysis_time	Time	PK	Y				Time of sample analysis in 24-hr (military) HH:MM format. Time zone and daylight savings must be same as analysis_date.
total_or_dissolved	Text(10)	PK	Y	N		rt_fraction.fraction	Sample fraction tested. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
column_number	Text(2)	PK	Y	NA		(Enumeration: 1C, 2C, or NA)	Either "1C" for first column analyses, "2C" for second column analyses, or "NA" for analyses for which neither "1C" nor "2C" is applicable. If any "2C" tests are reported, then there must be corresponding "1C" tests present also. Also, laboratories typically can report which of the two columns is to be considered "primary". This distinction is handled by the "reportable_result" field in the result table.
test_type	Text(10)	PK	Y	Initial		rt_test_type.test_type	Type of test in the laboratory. This field is used to distinguish between initial runs, re-extractions, reanalysis and dilutions. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
lab_matrix_code	Text(10)					rt_matrix.matrix_code	Code which describes the matrix as analyzed by the lab. May differ from sample_matrix_code. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
analysis_location	Text(2)		Y			(Enumeration: FL, LB, or FI)	Note where was sample analyzed. "FL" for mobile Field Laboratory analysis, "LB" for fixed based Laboratory analysis or "FI" for Field Instrument.
basis	Text(10)		Y	NA		(Enumeration: Wet, Dry, or NA)	Must be either "Wet" for wet weight basis reporting, "Dry" for dry weight basis reporting, or "NA" for tests for which this distinction is not applicable.
container_id	Text(30)						Sample container identifier.
dilution_factor	Numeric		Y	1.0			Dilution factor at which the analyte was measured effectively. Enter "1" if not diluted.
lab_prep_method_name	Text(20)					rt_prep_method.prep_method	Laboratory sample preparation method code. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD. If preparation is part of the analytic method, use the code "METHOD".
prep_date	Date						Date sample preparation began in MM/DD/YYYY format.
prep_time	Time						Time sample preparation began in 24-hr (military) format. Time zone and daylight savings must be same as analysis_date.
leachate_method	Text(15)						Laboratory leachate generation method name or description. The method name should be sufficient to reflect operation of the laboratory. Required for tests on leachate (TCLP, SPLP, etc.)
leachate_date	Date						Date of leachate preparation in MM/DD/YYYY format. Required for tests on leachate (TCLP, SPLP, etc.)

Field Name	Data Type [a]	Key	Required	Default	Parent	Lookup Table and Field	Comment
leachate_time	Time						Time of leachate preparation in 24-hr (military) format. Time zone and daylight savings must be same as analysis_date. Required for tests on leachate (TCLP, SPLP, etc.)
lab_name_code	Text(20)		Y			rt_company.company_code	Unique identifier of the laboratory. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
qc_level	Text(10)					(Enumeration: Screen or Quant)	Quality control level of analysis. May be either "screen" or "quant" (definitive).
lab_sample_id	Text(20)		Y				Laboratory LIMS sample identifier. If necessary, a field sample may have more than one LIMS lab_sample_id (maximum one per each test event).
percent_moisture	Numeric						Percent moisture of the sample portion used in this test; this value may vary from test to test for any sample. Report 70.1% as 70.1 not as 70.1%. Required for tests on solid matrices (soil, sediment, etc.)
subsample_amount	Text(14)						Amount of sample used for test. Required for tests on field samples.
subsample_amount_unit	Text(15)					rt_unit.unit_code	Unit of measurement for subsample amount. Required when reporting subsample_amount. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
analyst_name	Text(50)						Name or initials of laboratory analyst.
instrument_id	Text(60)						Instrument identifier.
comment	Text(255)						Comments about the test as necessary.
preservative	Text(20)					rt_preservative.preservative	Sample preservative used. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
final_volume	Text(15)						The final volume of the sample after sample preparation. Include all dilution factors.
final_volume_unit	Text(15)					rt_unit.unit_code	The unit of measure that corresponds to the final_volume. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.

Red lettered field names are required

Red lettered and underlined field names are required and lookups

Blue lettered field names are lookups

[a] For text data type, the number of allowable characters is listed in parentheses.

PK Primary Key

Table 4: Field descriptions for the AECOM Laboratory Result Table (LabRES)

Field Name	Data Type [a]	Key	Required	Default	Parent	Lookup Table and Field	Comment
sys_sample_code	Text(40)	PK	Y		AECOMLabTST.sys_sample_code AECOMLabSMP.sys_sample_code AECOMFSample.sys_sample_code		Unique sample identifier. Each sample must have a unique value, including spikes and duplicates. Laboratory QC samples must also have unique identifiers. Sample IDs for field samples must be reported exactly as found on the chain of custody form, and may not be changed for subsequent tests (dilution, re-analysis, leachate, etc.)
lab_anl_method_name	Text(20)	PK	Y		AECOMLabTST.lab_anl_method_name	rt_analytic_method.analytic_method	Laboratory analytic method name or description. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD. The method name should be sufficient to reflect operation of the laboratory.
analysis_date	Date	PK	Y		AECOMLabTST.analysis_date		Date of sample analysis in MM/DD/YY format. May refer to either beginning or end of the analysis as required by AECOM project manager.
analysis_time	Time	PK	Y		AECOMLabTST.analysis_time		Time of sample analysis in 24-hr (military) HH:MM format. Time zone and daylight savings must be same as analysis_date.
total_or_dissolved	Text(10)	PK	Y	N	AECOMLabTST.total_or_dissolved	rt_fraction.fraction	Sample fraction tested. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
column_number	Text(2)	PK	Y	NA	AECOMLabTST.column_number	(Enumeration: 1C, 2C, or NA)	Either "1C" for first column analyses, "2C" for second column analyses, or "NA" for analyses for which neither "1C" nor "2C" is applicable. If any "2C" tests are reported, then there must be corresponding "1C" tests present also. Also, laboratories typically can report which of the two columns is to be considered "primary". This distinction is handled by the "reportable_result" field in the result table.
test_type	Text(10)	PK	Y	Initial	AECOMLabTST.test_type	rt_test_type.test_type	Type of test in the laboratory. This field is used to distinguish between initial runs, re-extractions, reanalysis and dilutions. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
cas_rn	Text(15)	PK	Y			rt_analyte.cas_rn	CAS Registry Number for this analyte. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
chemical_name	Text(255)		Y				Chemical Name
result_value	Numeric						Analytic result reported at an appropriate number of significant digits. Must be identical with values presented in the hard copy. Leave blank for non-detects. Coeluting congeners must all be reported with the same value.
result_error_delta	Text(20)						Error range applicable to the result value; typically used only for radiochemistry results.
result_type_code	Text(10)		Y			rt_result_type.result_type_code	Must be either "TRG" for a target or regular result, "TIC" for tentatively identified compounds, "SUR" for surrogates, "IS" for internal standards, or "SC" for spiked compounds.
reportable_result	Text(3)		Y			(Enumeration: Yes or No)	Must be "Yes" for results considered to be reportable, or "No" for other results. Used to distinguish most appropriate result when multiple results are generated due to dual-column tests or re-tests. Exactly one result (cas_rn) for each sample should have reportable_result = "Yes".
detect_flag	Text(2)		Y			(Enumeration: Y or N)	Must be either "Y" for detected analytes or "N" for non_detects.
lab_qualifiers	Text(20)						Qualifier flags assigned by the laboratory. The lab is not restricted to using the qualifers in the reference values file; however, if a particular qualifier is used, the definition must be consistent with that in the reference values. The lab must provide an electronic key of laboratory-specific qualifiers used. Where a coeluting congener result is being reported, whether or not it is a detected result, this field will ALSO contain a "C", immediately followed by the lowest numbered congener

Field Name	Data Type [a]	Key	Required	Default	Parent	Lookup Table and Field	Comment
							of the coeluting set.
organic_yn	Text(1)		Y	Y		(Enumeration: Y or N)	Must be either "Y" for organic constituents or "N" for inorganic constituents.
method_detection_limit	Text(20)						Use the Method Detection Limit (MDL) for Organic compounds with the following exceptions; use the EDL for single component organics analyzed by isotope dilution methods; the highest EDL in the homolog for PCB homologs; the EDL of a single compent for Alkyl PAH homologs; and the instrument detection limit (IDL) for Inorganic compounds, per the contract. It must reflect such factors as dilution factors and moisture content.
reporting_detection_limit	Numeric						Use the value of the quantitation_limit except in the following cases: use the EDL for single component organics analyzed by isotope dilution methods; the highest EDL in the homolog for PCB homologs; the EDL of a single compent for Alkyl PAH homologs; and the result_value for radionuclides. Reflects conditions such as dilution factors and moisture content. Required for all results for which such a limit is appropriate. Must be identical to the non-detect value in the hard-copy report.
quantitation_limit	Text(20)						Concentration level above which results can be quantified with 95% confidence limit. Must reflect conditions such as dilution factors and moisture content. Required for all results for which such a limit is appropriate.
result_unit	Text(15)		Y			rt_unit.unit_code	Units of measurement for the result unit. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
detection_limit_unit	Text(15)					rt_unit.unit_code	Units of measurement for the detection limit(s). Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
tic_retention_time	Text(8)						TIC Retention Time in units of decimal minutes.
result_comment	Text(254)						Result specific comments.
qc_original_conc	Numeric						The concentration of the analyte in the original (unspiked) sample. Required for spikes. Not necessary for surrogate compounds or LCS samples (where the original concentration is assumed to be zero).
qc_spike_added	Numeric						The concentration of the analyte added to the original sample. Required for spikes, surrogate compounds, LCS and any spiked sample.
qc_spike_measured	Numeric						The measured concentration of the analyte. Use zero for spiked compounds that were not detected in the sample. Required for spikes, surrogate compounds, LCS and any spiked sample.
qc_spike_recovery	Numeric						The percent recovery calculated as specified by the laboratory QC program. Required for spikes, surrogate compounds, LCS and any spiked sample. Report as percentage multiplied by 100 (e.g., report "120%" as "120").
qc_dup_original_conc	Numeric						The concentration of the analyte in the original (unspiked) sample. Required for spike duplicates only. Not necessary for surrogate compounds or LCS samples (where the original concentration is assumed to be zero).
qc_dup_spike_added	Numeric						The concentration of the analyte added to the original sample. Required for spike or LCS duplicates, surrogate compounds, and any spiked and duplicated sample. Use zero for spiked compounds that were not detected in the sample. Also complete the qc-spike-added field.

Field Name	Data Type [a]	Key	Required	Default	Parent	Lookup Table and Field	Comment
qc_dup_spike_measured	Numeric						The measured concentration of the analyte in the duplicate. Use zero for spiked compounds that were not detected in the sample. Required for spike and LCS duplicates, surrogate compounds, and any other spiked and duplicated sample. Also complete the qc-spike-measured field.
qc_dup_spike_recovery	Numeric						The duplicate percent recovery calculated. Always required for spike or LCS duplicates, surrogate compounds, and any other spiked and duplicated sample. Also complete the qc-spike-recovery field. Report as percentage multiplied by 100 (e.g., report "120%" as "120").
qc_rpd	Numeric						The relative percent difference calculated. Required for duplicate samples as appropriate. Report as percentage multiplied by 100 (e.g., report "20%" as "20").
qc_spike_lcl	Numeric						Lower control limit for spike recovery. Required for spikes, spike duplicates, surrogate compounds, LCS and any spiked sample. Report as percentage multiplied by 100 (e.g., report "120%" as "120").
qc_spike_ucl	Numeric						Upper control limit for spike recovery. Required for spikes, spike duplicates, surrogate compounds, LCS and any spiked sample. Report as percentage multiplied by 100 (e.g., report "120%" as "120").
qc_rpd_cl	Numeric						Relative percent difference control limit. Required for any duplicated sample. Report as percentage multiplied by 100 (e.g., report "20%" as "20").
qc_spike_status	Text(10)						Used to indicate whether the spike recovery was within control limits. Use the "*" character to indicate failure, otherwise leave blank. Required for spikes, surrogate compounds, LCS and any spiked sample.
qc_dup_spike_status	Text(10)						Used to indicate whether the duplicate spike recovery was within control limits. Use the "*" character to indicate failure, otherwise leave blank. Required for any spiked and duplicated sample.
qc_rpd_status	Text(10)						Used to indicate whether the relative percent difference was within control limits. Use the "*" character to indicate failure, otherwise leave blank. Required for any duplicated sample.
uncertainty	Text(10)						Radiological analysis: uncertainty.
minimum_detectable_conc	Numeric						Radiological analysis: minimum detectable concentration.
counting_error	Numeric						Radiological analysis: counting error.
critical_value	Numeric						Radiological analysis: critical value.

Red lettered field names are required
Red lettered and underlined field names are required and lookups
Blue lettered field names are lookups
[a] For text data type, the number of allowable characters is listed in parentheses.
PK Primary Key

Table 5: Field descriptions for the AECOM Laboratory Batch Table (LabBCH)

Field Name	Data Type [a]	Key	Required	Default	Parent	Lookup Table and Field	Comment
sys_sample_code	Text(40)	PK	Y		AECOMLabTST.sys_sample_code AECOMLabSMP.sys_sample_code AECOMFSample.sys_sample_code		Unique sample identifier. Each sample must have a unique value, including spikes and duplicates. Laboratory QC samples must also have unique identifiers. Sample IDs for field samples must be reported exactly as found on the chain of custody form, and may not be changed for subsequent tests (dilution, re-analysis, leachate, etc.)
lab_anl_method_name	Text(35)	PK	Y		AECOMLabTST.lab_anl_method_name	rt_analytic_method.analytic_method	Laboratory analytic method name or description. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD. The method name should be sufficient to reflect operation of the laboratory. For example both "SW8080-pest" and "SW8080-PCB" may be necessary to distinguish between laboratory methods, while "SW8080" may not provide sufficient detail.
analysis_date	Date	PK	Y		AECOMLabTST.analysis_date		Date of sample analysis in MM/DD/YY format. May refer to either beginning or end of the analysis as required by AECOM project manager.
analysis_time	Time	PK	Y		AECOMLabTST.analysis_time		Time of sample analysis in 24-hr (military) HH:MM format. Time zone and daylight savings must be same as analysis_date.
total_or_dissolved	Text(10)	PK	Y	N	AECOMLabTST.total_or_dissolved	rt_fraction.fraction	Sample fraction tested. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
column_number	Text(2)	PK	Y	NA	AECOMLabTST.column_number	(Enumeration: 1C, 2C, or NA)	Either "1C" for first column analyses, "2C" for second column analyses, or "NA" for analyses for which neither "1C" nor "2C" is applicable. If any "2C" tests are reported, then there must be corresponding "1C" tests present also. Also, laboratories typically can report which of the two columns is to be considered "primary". This distinction is handled by the "reportable_result" field in the result table.
test_type	Text(10)	PK	Y	Initial	AECOMLabTST.test_type	rt_test_type.test_type	Type of test in the laboratory. This field is used to distinguish between initial runs, re-extractions, reanalysis and dilutions. Limited to values as found in the Reference values file, if additions must be made, they need to be approved by AECOM before submitting an EDD.
test_batch_type	Text(10)	PK	Y	Analysis		rt_test_batch_type.test_batch_type	Lab Batch type. Should be "Prep" or "Analysis" or "Leach"
test_batch_id	Text(20)		Y				Unique identifier for all lab batches. Each batch must contain at least one field sample, and samples can participate in more than one batch, as long as the batch type is unique.

Red lettered field names are required

Red lettered and underlined field names are required and lookups

Blue lettered field names are lookups

[a] For text data type, the number of allowable characters is listed in parentheses.

PK Primary Key

Appendix D:
Cumulative Historical Groundwater Results for OWDFMW01 Samples Collected During the Red Hill LTM Program

Appendix D: OWDFMW01 Long-Term Groundwater Monitoring Analytical Results

	Analyte Class & Method	TPH by 8260/8015[a]						BTEX by 8260								PAHs by 8270 SIM						Lead Scavenger by 8260/811/524.4[b]				SVOCs by 8270			
	Analyte/COPC	TPH-g		TPH-d		TPH-o		Benzene		Ethylbenzene		Toluene		Xylenes		1-Methyl-naphthalene		2-Methyl-naphthalene		Naphthalene		1,2-EDB		1,2-EDC		Phenol		2-(2-Methoxy-ethoxy)-ethanol [c]	
	CAS No.	Gas-Range		Diesel-Range		Oil-Range		71-43-2		100-41-4		108-88-3		1330-20-7		90-12-0		91-57-6		91-20-3		106-93-4		107-06-2		108-95-2		111-77-3	
OWDFMW01	DOH EAL (≤ 150 m)	300		400		500		5		7		10		13		2		5		12		0.04		5		58		800	
Sample ID	Date Sampled	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
OWDFMW01-WG-01	8/4/2009	30	U	171	U	—	—	**0.470**		0.31	U	0.31	U	0.62	U	0.0164	U	0.0164	U	0.0339	U	0.31	U	0.15	U	—	—	—	—
OWDFMW01-WG-02	10/13/2009	30	U	167	U	—	—	0.120	U	0.31	U	0.31	U	0.62	U	0.0168	U	0.0168	U	0.0346	U	0.31	U	0.15	U	—	—	—	—
OWDFMW01-WG-03	1/26/2010	60	U	**1,490**		—	—	0.240	U	0.62	U	0.62	U	1.24	U	0.032	U	0.032	U	0.0664	U	0.62	U	0.30	U	—	—	—	—
OWDFMW01-WG-04	4/26/2010	60	U	**288**	**J**	—	—	0.240	U	0.62	U	0.62	U	1.24	U	0.0352	U	0.0352	U	0.073	U	0.62	U	0.30	U	—	—	—	—
ES007	10/21/2010	12	U	81	U	—	—	0.32	U	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES008	10/21/2010	12	U	81	U	—	—	0.32	U	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES017	1/21/2011	12	U	81	U	—	—	**0.54**	**J**	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES018	1/21/2011	12	U	81	U	—	—	**0.69**	**J**	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES029	4/21/2011	12	U	81	U	—	—	0.32	U	0.46	U	**0.21**	**J**	**0.39**	**J**	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES031	4/21/2011	12	U	81	U	—	—	**0.29**	**J**	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES044	7/21/2011	12	U	81	U	212	U	0.32	U	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES045	7/21/2011	12	U	81	U	212	U	0.32	U	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES055	10/26/2011	12	U	81	U	—	—	0.32	U	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES056	10/26/2011	12	U	81	U	—	—	0.32	U	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES058	1/24/2012	12	U	81	U	212	U	**0.70**	**J**	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES059	1/24/2012	12	U	81	U	212	U	**0.58**	**J**	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES077	4/26/2012	12	U	**220**		—	—	**0.71**	**J**	0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES084	7/19/2012	12	U	81	U	—	—	**1.3**		0.46	U	0.34	U	0.38	U	0.12	U	0.12	U	0.1	U	0.4	U	0.28	U	—	—	—	—
ES008	11/7/2012	17	UJ	**2,500**		—	—	**0.38**	**J**	0.5	UJ	0.5	UJ	1	UJ	0.05	U	0.05	U	**0.025**	**J**	0.5	UJ	0.5	UJ	—	—	—	—
ES007	11/7/2012	30	UJ	**2,500**		—	—	**0.49**	**J**	0.5	UJ	0.5	UJ	1	UJ	0.05	U	0.05	U	**0.035**	**J**	0.5	UJ	0.5	UJ	—	—	—	—
ES016	1/30/2013	30	U	**1,000**		—	—	**0.39**	**J**	0.5	U	0.5	U	1	U	0.05	U	0.05	U	**0.032**	**J**	0.5	U	0.5	U	—	—	—	—
ES017	1/30/2013	30	U	**1,000**		—	—	**0.17**	**J**	0.5	U	0.5	U	1	U	0.05	U	0.05	U	**0.039**	**J**	0.5	U	0.5	U	—	—	—	—
ES025	4/24/2013	30	U	**1,900**		—	—	**0.82**	**J**	0.5	U	0.5	U	1	U	0.051	U	0.051	U	**0.063**	**J**	0.5	U	0.5	U	—	—	—	—
ES026	4/24/2013	30	U	**1,600**		—	—	**0.67**	**J**	0.5	U	0.5	U	1	U	0.050	U	0.050	U	**0.068**	**J**	0.5	U	0.5	U	—	—	—	—
ES034	7/24/2013	30	U	**470**		—	—	**0.42**	**J**	0.5	U	0.5	U	1	U	0.050	U	0.050	U	**0.081**	**J**	0.5	U	0.5	U	—	—	—	—
ES035	7/24/2013	30	U	**340**		—	—	**0.44**	**J**	0.5	U	0.5	U	1	U	0.048	U	0.048	U	**0.12**	**J**	0.5	U	0.5	U	—	—	—	—
ES043	10/23/2013	17	UJ	**170**		—	—	0.5	U	0.5	U	0.5	U	1	U	0.049	U	0.049	U	0.049	U	0.5	U	0.5	U	—	—	—	—
ES044	10/23/2013	14	UJ	**200**		—	—	**0.17**	**J**	0.5	U	0.5	U	1	U	0.049	U	0.049	U	0.049	U	0.5	U	0.5	U	—	—	—	—
ES053	1/27/2014	26	UJ	**170**		—	—	**0.15**	**J**	0.5	U	0.5	U	1	U	0.050	U	0.050	U	**0.093**	**J**	0.5	U	0.5	U	—	—	—	—
ES054	1/27/2014	23	UJ	**140**		—	—	0.5	U	0.5	U	0.5	U	1	U	0.050	U	0.050	U	**0.085**	**J**	0.5	U	0.5	U	—	—	—	—
ES086	4/23/2014	30	U	**270**		—	—	0.5	U	0.5	U	0.5	U	1	U	0.049	U	0.049	U	**0.035**	**J**	0.5	U	0.5	U	—	—	—	—
ES087	4/23/2014	31	UJ	**32**		—	—	0.5	U	0.5	U	0.5	U	1	U	0.050	U	0.050	U	**0.035**	**J**	0.5	U	0.5	U	—	—	—	—
ES109	7/24/2014	30	U	**17**	**J**	—	—	0.5	U	0.5	U	0.5	U	1	U	0.051	U	0.051	U	**0.031**	**J**	0.5	U	0.5	U	—	—	—	—
ES110	7/24/2014	30	U	**15**	**J**	—	—	0.5	U	0.5	U	0.5	U	1	U	0.050	U	0.050	U	**0.027**	**J**	0.5	U	0.5	U	—	—	—	—
ES121	10/22/2014	30	U	**19**	**J**	—	—	0.5	U	0.5	U	0.5	U	1	U	0.100	U	0.052	U	**0.047**	**J**	0.5	U	0.5	U	—	—	—	—
ES122	10/22/2014	30	U	**19**	**J**	—	—	0.5	U	0.5	U	0.5	U	1	U	0.100	U	0.052	U	0.052	U	0.5	U	0.5	UJ	—	—	—	—
ES121X	1/26/2015	30	U	**24**	**J**	—	—	0.5	U	0.5	U	0.5	U	1	U	0.100	U	0.052	U	0.052	U	0.5	U	0.5	U	—	—	—	—
ES122X	1/26/2015	30	U	**16**	**J**	—	—	0.5	U	0.5	U	0.5	U	1	U	0.100	U	0.051	U	0.051	U	0.5	U	0.5	U	—	—	—	—
ES137	4/22/2015	25	U	**120**		110	UJ	**0.070**	**J**	0.1	U	0.1	U	0.2	U	**0.023**		**0.017**	**J**	**0.025**		0.004	UJ	**0.010**	**J**	—	—	—	—
ES138	4/22/2015	25	U	**120**		**140**		0.1	U	0.1	U	0.100	U	0.2	U	**0.020**		**0.015**	**J**	**0.023**		0.004	UJ	**0.0081**	**J**	—	—	—	—
ES152	7/22/2015	25	U	**3,100**		**390**		0.100	U	0.1	U	0.1	U	0.2	U	**0.0088**	**J**	**0.0086**	**J**	**0.014**	**J**	0.004	U	**0.012**	**J**	—	—	—	—
ES153	7/22/2015	25	U	**3,000**		**330**		0.100	U	0.1	U	**0.060**	**J**	0.2	U	**0.0096**	**J**	**0.0097**	**J**	**0.016**	**J**	0.004	U	**0.012**	**J**	—	—	—	—
ERH002	10/19/2015	25	U	**680**		**100**	**J**	0.100	UJ	0.1	UJ	0.4	UJ	0.2	UJ	**0.019**	**J**	0.013	UJ	**0.025**		0.004	U	**0.0009**	**J**	—	—	—	—
ERH016	1/19/2016	25	U	**320**		69	UJ	0.1	U	0.1	U	0.18	UJ	0.2	U	**0.030**		**0.020**		**0.024**		0.004	U	**0.0096**	**J**	—	—	—	—
ERH030	4/19/2016	13	U	38	U	56	U	0.1	U	0.1	U	0.1	U	0.2	U	0.005	U	0.005	U	0.005	U	—	—	—	—	—	—	—	—
ERH031	4/19/2016	9	U	36	U	67	U	0.1	U	0.1	U	0.1	U	0.2	U	0.005	U	0.005	U	0.005	U	—	—	—	—	—	—	—	—
ERH044	7/19/2016	25	U	16	U	40	U	0.1	U	0.1	U	0.1	U	0.2	U	0.005	U	**0.0027**	**J**	0.019	U	—	—	—	—	—	—	—	—
ERH104	10/20/2016	18	U	**54**		**110**		0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH105	10/20/2016*	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH118	11/15/2016	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH119	11/15/2016	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH147	12/14/2016	18	U	58	U	**39**	**J**	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH148	12/14/2016	18	U	57	U	**46**		0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH184	1/12/2017	18	U	25	U	**45**		0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH184 (EPA split)	1/12/2017	25	UJ	75	U	300	U	0.2	U	0.2	U	0.2	U	0.5	U	0.025	UJ	0.025	UJ	0.025	U	0.0025	U	0.0025	U	2.5	U	—	
ERH227	2/9/2017	18	U	23	U	**44**		0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH227 (EPA split)	2/9/2017	25	UJ	75	U	300	U	0.2	U	0.2	U	0.2	U	0.5	U	0.025	UJ	0.025	UJ	0.025	U	0.0025	U	0.0025	U	2.5	UJ	—	
ERH286	3/8/2017	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U

Appendix D: OWDFMW01 Long-Term Groundwater Monitoring Analytical Results (cont'd)

	Analyte Class & Method	TPH by 8260/8015[a]						BTEX by 8260								PAHs by 8270 SIM						Lead Scavenger by 8260/811/524.4[b]				SVOCs by 8270			
	Analyte/COPC	TPH-g		TPH-d		TPH-o		Benzene		Ethylbenzene		Toluene		Xylenes		1-Methyl-naphthalene		2-Methyl-naphthalene		Naphthalene		1,2-EDB		1,2-EDC		Phenol		2-(2-Methoxy-ethoxy)-ethanol [c]	
	CAS No.	Gas-Range		Diesel-Range		Oil-Range		71-43-2		100-41-4		108-88-3		1330-20-7		90-12-0		91-57-6		91-20-3		106-93-4		107-06-2		108-95-2		111-77-3	
OWDFMW01	DOH EAL (≤ 150 m)	300		400		500		5		7		10		13		2		5		12		0.04		5		58		800	
Sample ID	Date Sampled	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
ERH286 (EPA split)	3/8/2017	25	UJ	75	U	300	U	0.2	U	0.2	U	0.2	U	0.5	U	0.025	UJ	0.025	UJ	0.025	U	0.0025	U	0.0025	U	2.5	U	—	
ERH321	4/4/2017	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH389	7/5/2017	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH435	10/26/2017	18	U	**110**		40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH566	3/14/2018	18	U	**310**	**J**	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH612	4/26/2018	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH658	7/26/2018	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH702	10/24/2018	18	U	**250**	**J**	**160**	**J**	0.3	U	5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	UJ
ERH757	1/23/2019	18	U	25	U	40	U	0.3	UJ	0.5	UJ	0.3	UJ	0.3	UJ	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	UJ
ERH809	4/25/2019	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	UJ
ERH865	7/24/2019	18	U	**210**		40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U
ERH931	10/23/2019	18	U	25	U	40	U	0.3	U	0.5	U	0.3	U	0.3	U	0.1	UJ	0.1	UJ	0.1	UJ	—	—	—	—	4	U	80	U
ERH995	1/22/2020	18	U	**120**		**120**		0.3	U	0.5	U	0.3	U	0.3	U	0.1	U	0.1	U	0.1	U	—	—	—	—	4	U	80	U

Notes: All values are in µg/L (microgram per liter).

Current LTM program of OWFMW01 includes analysis of: TPH-g and BTEX (SW-846-8260);TPH-d and TPH-o (SW-846-8015); naphthalene and 1- & 2-methyl naphthalenes (SW 846-8270SIM); phenol and 2-(2-methoxyethoxy)-ethanol (SW-846-8270).

DOH Tier 1 Environmental Action Levels, Table D-1a (DOH 2017). Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS located within 150 meters of release site).

Green	COPC was detected in at least one collected sample between August 2009 and July 2019.
Blue highlight	exceeds current DOH EAL
Bold	Detected value

— = no data or COPC not analyzed for during sampling event

µg/L = microgram per liter

BTEX = benzene, toluene, ethylbenzene, and xylenes

CAS No. = chemical abstract services number

COPC = chemical of potential concern

DOH = Department of Health, State of Hawai'i

EAL = environmental action level

EDB = ethylene dibromide

EDC = ethylene dichloride

ID = identification

J = estimated value

PAH = polynuclear aromatic hydrocarbon

Q = results qualifier

SVOC = semivolatile organic compound

TPH = total petroleum hydrocarbons

TPH-d = TPH-oil range organics

TPH-g = TPH-gasoline range organics

TPH-o = TPH-diesel range organics

U = the compound was analyzed for but not detected above the stated limit - non-detected value.

UJ = estimated non-detect values

[a] TPH-g analyzed by either 8015 or 8260. TPH-d & -o analyzed by 8015

[b] Analyzed by either 8260, 8260 SIM, 8011, 504.1, and/or 524.2.

[c] EPA RSL Tap water RSL (THQ= 1) is used for tier I screening for 2-(2-Methoxyethoxy)-ethanol (EPA 2019).

Appendix E:
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Appendix F:
Concurrence/Response to Comments

From: Reyes, Maria Eloisa Q <maria.reyes@doh.hawaii.gov>
Sent: Wednesday, January 27, 2021 9:41 AM
To: Ibarra, Tracy-Joy N CIV USN NAVFAC HAWAII PEARL (USA)
Cc: Kotoshirodo, Jan H CIV USN NAVFAC HAWAII PEARL (USA); TU, LYNDSEY; Lichens, Christopher
Subject: [Non-DoD Source] Re: Red Hill OWDF Draft SA WP

Hi Tracy,

There are no further comments from DOH.

Thanks,
Maria

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From: Ibarra, Tracy-Joy N CIV USN NAVFAC HAWAII PEARL (USA)
Sent: Thursday, January 21, 2021 3:40 PM
To: Reyes, Maria Eloisa Q
Cc: Kotoshirodo, Jan H CIV USN NAVFAC HAWAII PEARL (USA); TU, LYNDSEY; Lichens, Christopher
Subject: [EXTERNAL] RE: Red Hill OWDF Draft SA WP

Hi Maria,

Greatly appreciate the quick turnaround in comments, and the support in our monitoring well installation efforts and beginning this initial phase of field work this month for OWDF's Site Assessment!

An additional well cluster to the northeast corner of the site (see attached and below) will be added to the work plan; and the proposed modifications to the Draft SA WP are detailed below based on latest DOH comments received.

Please let me know if there are objections to the proposed modifications. If there no objections, I will have the Draft SA WP modified accordingly and finalized for immediate distribution.

Thank you!

1, 2, 3, 4, 10, 11, 12, 13, & 14. Comments acknowledged; thank you.

5, 6, 7, 8, & 9. The Navy agrees with the comment that there are various uncertainties that the upcoming investigation should address. To this end, seven monitoring well clusters are now proposed to be advanced, which will provide data that can address existing data gaps and allow for refinement of the CSM. The following modifications will be made to the work plan:

A. The Navy agrees that the existing data confirms that the aquifer is confined, but contains some data gaps regarding the nature of the confinement. Therefore, the investigation will gather far more site-specific geologic, hydrogeologic, and hydraulic data than is now available from seven new well clusters (anticipated to include approximately 14 wells total) located across the site. Additionally, if it is determined that further evaluation is warranted after the Site Assessment, additional investigations may be conducted at the site. The fourth paragraph of Section 10.1.7.1 of the work plan will be modified as follows:

   A specific exception to the general high-permeability nature of basal aquifer material is massive basalt, which is targeted for production at the nearby Halawa Quarry and was encountered during RI drilling in each basal borehole at the OWDF (DON 2000). Layers of this comparatively low permeability material inhibit groundwater storage and transmission (Wentworth 1951). Thus, during drilling of the deep wells at the OWDF, a layer of massive basalt (dry to very dry in some areas) was encountered to depths below zero ft msl in each of the three deep borings. Other materials encountered near the groundwater surface included breccia. These materials caused locally confined conditions, inhibiting vertical flow, and indicating that there may be little to no hydraulic communication between the perched and basal aquifers beneath the OWDF. However, existing data is not conclusive and more information will be gathered in the proposed investigation to address data gaps, as described in this work plan.

B. The OWDF groundwater gradients and the estimated flow directions shown on Figure 11 were calculated during the RI using data from only three monitoring wells. Thus, interpretations from this limited data set are not expected to be definitive. Moreover, the relationship between groundwater flow and gradients with respect to the operation of nearby Red Hill Shaft is not clear and warrants further investigation, which is why this investigation proposes gathering far more data and conducting further studies before drawing any final conclusions. For example, the WP proposes the installation of seven new well clusters and conducting an extensive groundwater transducer study, collecting synoptic water level data every 10 minutes over the course of one year, which will span far more pumping conditions than were encompassed by the RI groundwater study. Text in Section 10.1.7.2 of the work plan will be modified as follows:

Continuous monitoring of the three basal aquifer monitoring wells was conducted from August 18 through October 6, 1998, during which time operation of the nearby Red Hill Shaft water supply pumps varied and was measured (WP Supplement, Figure 10). Measured basal water levels in the OWDF basal aquifer wells ranged from 17.73 to 15.98 ft msl, correlating to the expected basal aquifer elevation for the area. Water levels in all three wells fluctuated in unison in relatively rapid response to pumping conditions. The plots show that drawdown at the pumping station was as much as approximately 6 ft when both pumps were on, and the differences in groundwater elevations between the three OWDF monitoring wells were generally less than 0.5 ft and remained fairly constant during different pumping conditions.

The basal aquifer wells were installed in a triangular pattern to allow basal groundwater flow direction beneath the OWDF to be estimated using simple triangulation. The anticipated overall regional direction of basal groundwater flow based on regional tendencies is seaward or roughly west of the OWDF, but local variations may be present. In the three OWDF basal wells, MW08 (now named OWDFMW01) consistently demonstrated the lowest basal groundwater elevation of the three wells, and simple triangulation of measured basal groundwater elevations in the three OWDF wells suggested that the basal aquifer groundwater gradient was oriented in easterly and northeasterly directions, roughly toward the nearby Red Hill Shaft during some events. The OWDF-specific basal groundwater flow direction appeared to be relatively consistent with time, at least while the Red Hill Shaft pumps were active, however, the study was relatively brief, included monitoring of only three onsite wells, and may reflect transient conditions from which final conclusions cannot be drawn. The calculated basal groundwater gradients (changes in measured basal aquifer elevation over distance between monitoring wells) ranged from 0.038 to 0.048 percent during the July to September 1998 period (DON 2000) (WP Supplement Figure 11). Thus, although simple triangulated gradient vectors varied in direction from pointing directly towards the Navy supply well located approximately to the east, to more north or northeasterly directions, it is not evident whether any gradient data free of the impact of pumping were recorded. It was concluded during the RI that the flow of basal groundwater beneath the site was strongly influenced by Red Hill Shaft. More information is required prior to drawing any conclusions, including better special resolution (to be provided by the new wells), better temporal resolution, and data gathered under more varieties of different transient and steady pumping conditions (to be automatically recorded and gathered over the course of a year).

C. Chloride in groundwater in the vicinity of OWDFMW01 was elevated far beyond what would be expected, which will be investigated during the Site Assessment. In order to address this data gap, the WP proposes advancing seven well clusters and evaluating groundwater chemistry at each well during four quarterly monitoring events. Newly gathered data will be used to determine the lateral extent of elevated chloride concentrations. The text related to chloride in Section 10.1.7.2 in the work plan will be modified as follows:

The general chemistry differed between the perched groundwater and basal aquifer. Concentrations of the major anions chloride and sulfate and the major cations calcium, potassium, and sodium were higher in the basal aquifer than in perched groundwater (WP Supplement, Figure 12). In addition, pH measurements indicate that the pH values were higher in the basal aquifer than in perched water. The RI attributed the high pH in basal water to basal rock and saprolite and the large amounts of grout pumped into the basal aquifer rock during Phase II well installation and borehole abandonment of MW07 and a test boring. It was also noted that total dissolved solids (TDS) were elevated in MW08 (OWDFWM01). In addition, chloride in groundwater collected from well OWDFMW01 during the groundwater long term monitoring program has been significantly elevated from that measured in other area monitoring wells, well beyond what would be expected in this area. The extent of elevated chloride is a phenomena that will be further analyzed using the vastly expanded OWDF monitoring well network proposed in this investigation during the four quarterly groundwater monitoring events.

10. An additional well cluster (OWDFMW08) will be added to the well drilling program for a total of seven monitoring well clusters. This newest well cluster will be positioned in the northeast corner of OWDF to provide additional detail regarding the uncertainties described above and to help determine groundwater flow and chemistry in the direction of Halawa Industrial Park. The WP will be revised accordingly to reflect changes to the program. Similarly, the WP Supplement Figure 16 (attached) will be revised to include the proposed location for well cluster OWDFMW08.

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From: Reyes, Maria Eloisa Q <maria.reyes@doh.hawaii.gov>
Sent: Thursday, January 7, 2021 3:07 PM
To: Ibarra, Tracy-Joy N CIV USN NAVFAC HAWAII PEARL (USA) <tracy-joy.ibarra@navy.mil>
Cc: Kotoshirodo, Jan H CIV USN NAVFAC HAWAII PEARL (USA) <jan.kotoshirodo@navy.mil>; TU, LYNDSEY <Tu.Lyndsey@epa.gov>; Lichens, Christopher <lichens.christopher@epa.gov>
Subject: [Non-DoD Source] Red Hill OWDF Draft SA WP

Hi Tracy,

Here are DOH comments for the Navy RTCs:

1 a & b. no comment

2 a, b, c, & d. no comment

3. no comment

4. no comment

5, 6, 7, 8, & 9. The DOH's response to Navy RTCs 5, 6, 7, 8, and 9 are combined as they deal with the current conceptual site model (CSM) of groundwater flow, contaminant transport, and data interpretation that supports that CSM. The Work Plan (WP) Objective 1 states that investigation will re-evaluate conditions at the site and the underlying aquifers; Objective 2 states the investigation will update the CSM. Both are very important objectives that require identifying data gaps, where the current conceptual model and data are in conflict. There is a need to clearly describe approaches to fill the data gaps and resolve any conflicts between the data and the CSM. Much of the WP appears to accept the current CSM with no identification of data gaps or data conflicts regarding the CSM. There are major areas of data gaps/misalignment that the WP should address to meet the Objectives 1 and 2:

A. The nature of the apparent confinement of the basal aquifer in the OWDF area (RTCs 5, 6, and 7);
B. The groundwater gradient and inferred groundwater flow trajectories in the OWDF area (RTCs 7 and 8); and
C. The groundwater chemistry and the implications for groundwater flow trajectory and contaminant transport (RTCs 8 and 9).

As pointed out in the WP, boreholes drilled in the OWDF didn't encounter saturated conditions until well below the regional groundwater elevation. The WP describes the basal groundwater as being confined by a thick layer of very dry massive basalt with the water levels rising in the borehole after this layer was penetrated. However, this description is inconsistent with a careful review of the geologic logs from the 2002 OWDF Report. Other factors may be influencing entry of the groundwater into the boreholes. For example, OWDF-MW09 was the only well where water entered the borehole immediately after penetrating through a basalt layer. However, the basalt was highly weathered and only ten feet thick. The major formation from the static water table to the first encountered water was interbed gravely clay and clayey gravel. At OWDF-MW08, the drill string was still in basalt when groundwater was encountered. In OWDF-MW06, groundwater was first encountered at 6 feet below the basalt, in the breccia. These geologic observations are inconsistent with what the WP concludes as the cause of the apparent groundwater confinement. The WP should note the inconsistencies in the geologic observations and describe how to reconcile the CSM with the observed geology and hydrologic observations.

Undoubtedly, as the Navy's RTC states, pumping of the Red Hill Shaft exerts an influence on the groundwater flow trajectory beneath the OWDF. An inspection of Figure 11, in the Navy's RTCs, shows the measured groundwater gradient for four different days compared to the direction from the OWDF to the Red Hill Shaft. Three of the four plotted groundwater gradients point north, and some cases, well north of the red arrow indicating the direction to the Red Hill Shaft. Figure 1 (attached) is a scaled diagram of the OWDF wells, the geographic centroid of those wells and the infiltration gallery for the Red Hill Shaft. Scaled vectors are drawn from the centroid of the OWDB wells with the length of the vectors proportional to the measured gradient. Only the vector representing the measurements taken on August 18, 1998 points toward the most productive zone of the Red Hill Shaft infiltration gallery. One interpretation could be that the orientation of the vectors relative to the Red Hill Shaft represent different draft rates of the Red Hill Shaft. When there is little pumpage, the groundwater beneath OWDF flows to the northeast. There seems to be no indication of ambient groundwater flow in seaward direction to the west. The WP should note the inconsistencies in the hydrologic observations and describe how to reconcile the CSM with the observed geology and hydrologic observations.

The chemistry of the OWDF and other wells with the Red Hill Bulk Fuel Storage Facility is quite diverse. For example, the chloride concentration differs by more than an order of magnitude in compact area of the Red Hill Facility that is separated from the Harbor shoreline by 1.7 miles of poorly permeable rock. This poorly permeable rock prevents any direct marine influence on the groundwater chemistry. Chloride is recognized as a natural groundwater tracer, and the large chloride contrast within the OWDF and Red Hill wells in general, strongly indicate a complex compartmentalized groundwater system. The WP should note the inconsistencies in the geologic observations and describe how to reconcile the CSM with the observed geology and hydrologic observations.

More in-depth discussion of and plans to resolve the various conflicting or other confusing data should be part of the WP. It appears most of the discussion of site conditions was taken directly from the 2002 OWDF report with little updated interpretation.

10. Since the Navy claims that "…it is not impossible for contamination from Halawa Industrial Park, if present, to migrate.", add another well cluster to the northeast corner of the site. OWDFMW05, OWDFMW06, and OWDFMW07 are positioned between the OWDF and the State of Hawaii Department of Agriculture Animal Quarantine Station. Adding a well cluster, in the northeast corner of OWDF, will help determine if contamination from Halawa Industrial Park is migrating to OWDF.

11. no comment

12. no comment

13. no comment

14a. RTC acknowledged. Surface soil sampling using DU-MIS will not be required during this field effort. Discrete samples for subsurface soil delineation of COPCs will not be accepted, as they are only screening samples and will not be representative of the area being sampled. DOH will not accept the use of discrete sample data for final decision-making as part of an environmental investigation.

14b & c. no comment

The Navy may proceed with monitoring well installation with the additional well cluster in the northeast corner of the site.

Please let me know if you have any questions. Thanks for your patience.

Maria

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New HEER Office Website:
https://health.hawaii.gov/heer/

Project Title: Draft Site Assessment Work Plan
Red Hill Oily Waste Disposal Facility Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Maria Eloisa Q. Reyes, State of Hawaii Department of Health,
Hazard Evaluation and Emergency Response Office
Date: October 21, 2020

Item	Section No.	Comment
1	Worksheet 10: Conceptual Site Model	a. Please refine the conceptual site model (CSM) to include subsurface conditions after the Removal Action. Most of the CSM appears to lean on subsurface conditions prior to excavation (e.g. Figure 7). Include a scale in Figure 7 on how deep the basin area was excavated and how it was refilled. It is unlikely that the surface layers as shown in the figure are still that continuous. The excavation may have led to a difference in local flow and aquifer recharge conditions (a.k.a. preferential pathways). The timing of COPC occurrence should be investigated in relation to excavation events. Once this is included in the CSM, re-evaluate if the well/boring locations are still appropriate. b. The DOH disagrees with the Navy's characterization of the TPH-d chromatographs. Chromatographic signatures of TPH-d detections, during quarterly monitoring events in 2010, 2012, 2013, and 2015, are not expected to resemble fresh petroleum fuel standards. Once released to the environment, the mixture of hydrocarbon compounds starts undergoing changes, which results in different chromatographic signatures from that of fresh petroleum fuel standards. The fact that a chromatograph does not resemble a fuel standard does not mean that the TPH-d was not a result of operations at Red Hill Bulk Fuel Storage Facility (RHSF) nor does it mean there are no health risks.

Response:

a. The CSM has been revised to include additional details on subsurface conditions after the Removal Action, including the dimensions of the basin area excavation, soil treatment, fill, grading, and cap construction. Text in Section 10.1.1.1 (2nd bullet point, last sentence) has been revised to read:

> "The excavation covered an area of approximately 10,000 square feet and had a maximum vertical extent of approximately 28 feet bgs (i.e., above the perched aquifer). The excavated soil was transported off-site for treatment by thermal desorption and used as clean backfill in the excavation. To prevent rainfall recharge at the site, the soil was graded to assure positive drainage away from the former excavation, and most of the Stilling Basin area was capped with a low-permeability liner and asphaltic pavement. The area is now occasionally used for parking and as a staging area (WP Supplement Figure 3)."

Additionally, Figure 7 is a schematic presentation of the CSM that is not to scale. Therefore, in response to this comment, an additional figure from the Remediation Verification Report (RVR) has been added as the new Figure 3 (included with these responses to comments as Attachment A) in the work plan (WP) to show the details of the removal action, including excavation extents and the construction of the composite cap placed below the asphalt that inhibits recharge into the former basin area. As depicted on Figure 3, the Stilling Basin was excavated from the ground surface to approximately 28 feet below ground surface (bgs) (92 feet above mean sea level [msl]). The site was also graded to promote surface drainage away from the excavation and capped to prevent rainfall recharge through this area. Perched groundwater was encountered in all well borings advanced during the OWDF RI at depths greater than 28 feet bgs (i.e., below the maximum depth of excavation), and there was no indication that the excavation encountered groundwater. Although we agree that the excavation could have altered localized flow and recharge conditions above the perched aquifer, the Removal Action should have decreased infiltration, and there is no indication that the excavation impacted or altered the perched aquifer itself or the underlying aquitard. As a result, we do not recommend any changes to the proposed well locations at this time.

b. Comment acknowledged. The intent of the CSM in Worksheet 10 is to present historical and current information from available sources to illustrate what is known regarding the existing or potential impacts at the site. Therefore, we performed a preliminary comparison of the ODWFMW01 chromatograms not only to fresh petroleum fuel standards, as indicated in the comment, but also to chromatograms for other area wells that are known to have been impacted. Based on this preliminary review, the WP merely stated that "constituents reported as "TPH-d" in groundwater near the RHSF <u>are not necessarily</u> the same constituents that constitute the "TPH-d" detected at the OWDF" (underlined emphasis added). We agree with the comment that current data does not conclusively show that there are no risks; therefore, no conclusions are being drawn at this point and, as stated in the WP, this proposed "investigation has been designed in part to further evaluate" this and related data. Additionally, if it is determined that further evaluation is warranted after the Site Assessment, additional investigations may be conducted at the site.

Project Title: Draft Site Assessment Work Plan
Red Hill Oily Waste Disposal Facility Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Maria Eloisa Q. Reyes, State of Hawaii Department of Health,
Hazard Evaluation and Emergency Response Office
Date: October 21, 2020

Item	Section No.	Comment
2	Section 10.1.1.1, OWDF Description and History	a. Oily Waste Disposal Pit – Please provide information on the known or potential use of fire-fighting foam or other chemicals that might have included high concentrations of PFASs in this exposure area of concern (EAOC). b. Stilling Basin – Please provide information on the known or potential use of PFAS-containing chemicals in this EAOC. c. Underground Piping and Delivery (UPD) System – Please provide more information on the portions of the UPD system beneath the Stilling Basin and leading to the South Halawa Stream, that were grouted, capped, and abandoned in place during the 1995 Removal Action. d. Former Transformer Area – Please provide a summary of past PCB investigations conducted in this EAOC.

Response:

a. and b. We reviewed all available information in response to this comment and did not encounter any evidence or suggestion that former operations or waste disposal practices included wastes that contained PFAS. Rather, records indicate that the RHSF did not have a fire suppression system until after 2015 (*see* FY15 MILCON P-1551 [DESC 1551] Upgrade Fire Suppression and Ventilation Systems, Red Hill, at Joint Base Pearl Harbor-Hickam Hawaii). Relatedly, based on discussions of this comment with facility operators, prior to the 2015 MILCON project, select portions of the facility within confined spaces employed carbon dioxide for fire suppression and there we no records of historical fire-fighting foam use or capabilities. In addition, both the Red Hill Bulk Fuel Storage Facility and the OWDF were excluded for further PFAS investigation in the *Draft Preliminary Assessment of Potential Per- and Polyfluoroalkyl Substances on National Priorities List Sites at Joint Base Pearl Harbor-Hickam Oahu HI* (DON 2019) because that investigation did not reveal any indication of PFAS use or disposal. Therefore, there is no indication that wastes received by OWDF contained PFAS-contaminated material from the tanks. No records indicate whether any fire control measures were used during historical waste burning activities (it is conceivable that the nearby water pump was available as a standby for fire control). In any case, we could not find any records of fire-fighting foam use or capability during the time of operation of the Disposal Pit or the Stilling Basin.

c. A new figure from the RVR (Figure 4, included with these responses to comments as Attachment B) has been added to the WP to show the portions of the UPD system that were grouted, capped, and abandoned in place during the 1995 Removal Action. In addition, text in Section 10.1.1.1 (5th bullet point, last sentence) has been revised to state:

> "Most portions of the UPD system beneath the Stilling Basin and leading to South Halawa Stream were excavated and removed during the 1995 Removal Action. Only two sections of piping were grouted, capped, and abandoned in place. These sections include a 10-inch gravity drain, flowing northwest away from the Stilling Basin, and a short section of 10-inch pipe which could not be removed because of its location under a concrete slab (WP Supplement Figure 4) (DON 1996b)."

d. Additional information regarding the Former Transformer Area has been added to Section 10.1.1.1:

> "*The Former Transformer Area:* Site constructions photographs taken in 1943 show that transformers were located on site adjacent to the two 8,000-gallon ASTs. However, subsequent aerial photos taken in 1949 and thereafter indicate that the transformers were likely removed from the site prior to 1950s. The Former Transformer Area was not believed to be impacted by oily wastes but was investigated because the transformers located on site prior to 1949 posed a potential source of PCBs (DON 1996). The Phase I RI collected twelve primary samples from trenches, shallow soil borings, and surface soil locations in this area. Trench samples were analyzed for VOCs, PAHs, TPH, pesticides, organolead, and metals. The shallow and surface locations were analyzed for PCBs only. Aroclor 1260 was detected in four samples with detected concentrations ranging from 0.1 to 0.48 mg/kg, all of which are below the current total PCB DOH EAL (1.2 mg/kg [DOH 2018]).The RI concluded that contamination at this EAOC did not represent a significant risk to human health or the environment, and no further action was recommended for this EAOC (DON 1996), and DOH later agreed."

Item	Section No.	Comment
3	Section 10.1.1.2, Red Hill Shaft Description and History	Confirmed detections of petroleum analytes, such as ethylbenzene, at a site with known fuel releases do not require repeat detections to be verified. Please remove the phrase "thus those Fourth Quarter 2018 detections could not be verified".

Response: The phrase "thus those Fourth Quarter 2018 detections could not be verified" has been removed as requested; the phrase "but were not detected during any previous or subsequent monthly quarterly sampling events" has been retained.

Project Title: Draft Site Assessment Work Plan
Red Hill Oily Waste Disposal Facility Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Maria Eloisa Q. Reyes, State of Hawaii Department of Health,
Hazard Evaluation and Emergency Response Office
Date: October 21, 2020

Item	Section No.	Comment
4	Section 10.1.1.3, RHSF Description and History, Red Hill Tank 5 2014 Release	The DOH disagrees that impacts to the basal aquifer at the OWDF may not be related to the Red Hill Tank 5 Release in 2014. The Navy's long-term monitoring (LTM) program for RHSF is inadequate to conclude that the Red Hill Tank 5 Release in 2014 did not impact the basal aquifer at OWDF.

Response: Comment acknowledged. However, as shown on the WP Supplement Figure 11 (now Figure 14) and Appendix D of the WP, eight of the eleven (over 72 percent) TPH exceedances at OWDFMW01 occurred before the 2014 Tank 5 Release. It is not possible for the 2010-2013 detections to have been related to the 2014 release. In any case, no conclusions (other than the preceding) are being drawn at this time (rather, the WP accurately states that detections "may not be related to the Red Hill Tank 5 Release in 2014"). As stated in the WP, the purpose of this investigation is to evaluate impacts to the basal aquifer at OWDF. Additional investigation also can be undertaken at the site after the work proposed in the WP is completed, if warranted. No change is recommended.

Item	Section No.	Comment
5	Section 10.1.6.2, Site Geology and Soils, last paragraph	Please clarify if the "very dry" massive basalt layer was encountered in each of the three deep borings installed during the RI. Information provided in the documents suggest that this unit was only encountered in MW8 (now OWDFMW-1).

Response: The Phase II RI Report confirms that, based on data from all three basal monitoring wells that were completed, "the basal aquifer beneath the OWDF is locally confined" throughout and beyond the OWDF site. Table 3-5 of the Phase II RI Report and the accompanying text states that:

> "basal groundwater elevation expected around Halawa Valley ranges from 14 to 17 feet above msl" but "Initially encountered depths to groundwater were … [at] elevations of 1.3, 2.8, and 20.3 feet below msl. After release from confinement, groundwater potentiometric heads in these wells rose between approximately 17 to 36 feet." (Phase II RI Section 3.5.2.3)

This is consistent with the thick, massive, basalt confining layer depicted in the Phase II RI boring log for OWDFMW01 reproduced as Appendix G of the WP Supplement, as well as the cross-sections reproduced as the WP Supplement Figure 3 (now Figure 5) and Figure 4 (now Figure 6), and boring logs for the other two wells established during the Phase II RI. The Phase II RI also states that:

> "Most, if not all of groundwater infiltrating downward through the shallow subsurface is intercepted by the uppermost perching layer. Groundwater potentially migrating past this level will be intercepted by underlying low-permeability clay layers. The zone between the perching horizons and the basal aquifer was observed to be very dry, indicating the perched groundwater transport to that depth is incomplete or very minimal. Additionally, the basal groundwater behavior indicates the basal aquifer itself is locally confined. Information from borings conducted offsite indicate that confinement of the basal aquifer extends beyond the confines of the OWDF." (RI WP Section 3.5.2.5, underlined emphasis added)

Further review of the boring logs for the three basal Phase II RI wells show that, while it is true that one of the logs indicates moisture in some areas *above* the elevation of the regional basal groundwater potentiometric surface, the relative moisture or dryness of the cores samples was not consistently noted on the boring logs. Nevertheless, the logs for wells MW06 and MW08 (now OWDFMW01) both indicate that, at the approximate elevation of the regional groundwater potentiometric surface (i.e., 15-20 feet msl), the massive basalt was "dry" or "very dry" and "hard" or "very hard." The log for MW09, by contrast, contains less detail at the relevant depth, and merely indicates "**BASALT**; highly weathered basalt", without any indication of wetness or dryness. In all three wells, groundwater was generally first encountered below mean sea level, and then rose substantially to the regional potentiometric level after penetration of the massive basalt.

Thus, to summarize, two of the three well logs indicate dry or very dry conditions, the third log is silent as to moisture at this depth, all three logs confirm massive basalt confining conditions, and the report characterized the conditions throughout and beyond the facility as locally confined by "very dry" basalt. Consequently, no changes are recommended at this time and these RI conclusions will be revisited once the proposed investigation yields additional clarifying data.

Project Title: Draft Site Assessment Work Plan
Red Hill Oily Waste Disposal Facility Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Maria Eloisa Q. Reyes, State of Hawaii Department of Health,
Hazard Evaluation and Emergency Response Office
Date: October 21, 2020

Item	Section No.	Comment
6	Section 10.1.7.1, Red Hill Regional Hydrology, Basal Aquifer	a. The groundwater elevation just south of Schofield Dam varies from 21 to 24 ft msl, not 30 ft msl as stated in the document. URS (now part of AECOM) did the LTM for Waikakalau Fuel Storage Facility immediately south of the South Schofield Dam for a number of years; water levels were recorded during that time. b. Mauka to makai groundwater flow has not been demonstrated to be occurring at Red Hill. In fact, elsewhere in the work plan, the groundwater has been described to be flowing directly up ridge. c. Please clarify that MW8 (now OWDFMW-1) was the only notable occurrence of massive lava resulting in a dry hole to below the water table. See comment 5.

Response:

a. The 30 feet msl elevation cited in the WP was taken from the USGS *Summary of the Oahu, Hawaii, Regional Aquifer-System Analysis* (USGS 1997). In considering this comment, we were able to locate the *Final Waikakalaua Fuel Storage Annex Comprehensive Remedial Investigation Report OU-1 and OU-2 Hickam POL Facilities, Oahu, Hawaii, United States Air Force* (USAF 2007), which appears to be related to the documents referenced in this comment. That document states that "monitoring wells installed immediately south of the southern Oahu Schofield water region boundary have recorded basal aquifer elevations to be approximately 20 ft msl (USAF 2007). Depth to groundwater of the Pearl Harbor basal aquifer system generally decreases from north to south but may vary locally in the vicinity of streams or other surface water bodies." Therefore, the WP text has been revised to state:

> "Basal groundwater elevations in the southern Oahu region range from approximately 0 feet msl near the shoreline to elevations ranging between 20 and 30 feet msl in the vicinity of the southern Oahu Schofield water region boundary (USAF 2007; USGS 1996)."

b. The proposed OWDF investigation focuses on conditions at the OWDF. While we understand there may be some disagreement regarding overall groundwater flow and the nature of potential localized variances that may be present, the WP does not describe groundwater at Red Hill as generally flowing "up ridge." Rather, the WP focuses on the OWDF and indicates that, according to the RI data and analyses, the OWDF appears to be within the capture zone of the nearby, relatively high-capacity supply well. The Phase II RI groundwater study (illustrated on the WP Supplement Figure 8 [now Figure 10]) indicated that all of the RI wells responded rapidly and almost uniformly to changing pumping conditions. For further information, a figure from the Phase II RI has been added to the WP (Figure 11; included with these responses as Attachment C), which shows the estimated flow directions at the OWDF, based on a simple triangulation of data conducted during the RI without consideration of potential heterogeneities, anisotropy of the aquifer's parent bedrock, or transient conditions. Due to the scale of this figure, the supply well location cannot be displayed; therefore, a red arrow pointing to the Red Hill Shaft pump is superimposed. The figure shows that the basal aquifer gradient was generally towards the nearby pumping station, as might be expected. Also, as shown on WP Supplement Figure 8 (now Figure 10), the pump station cycled on and off during the course of the study, such that it is not surprising that the groundwater gradient did not completely stabilize but instead varied during the study, with gradients generally, but not always precisely, towards the supply well.

   We assume this comment is directed to the statement in Section 10.1.7.1 in the WP that, in Hawaii and on other islands, "Basal groundwater potentiometric elevations typically slope downward in the seaward direction. Thus, in the vicinity of Red Hill, the overall regional flow of basal groundwater is expected to be from higher mountain elevations (mauka) toward Pearl Harbor (makai)." However, the WP goes on to state that, "The potential exists for variances in the localized flow directions from the overall regional flow pattern," which is consistent with this comment. In any case, the OWDF investigation will focus on conditions in and around the OWDF; thus, later on in this section, the WP notes that "the OWDF RI documented localized flow in the vicinity of the OWDF toward Red Hill Shaft during pumping conditions and rapid response (potentiometric drawdown and recovery) to changing pumping rates (DON 2000)" (underlined emphasis added). No changes are recommended to any of these statements at this time. Moreover, this Site Assessment is designed to provide significantly more data about flow in the vicinity of the OWDF than is currently available, which will be analyzed in more detail, and no final conclusions are being drawn before the data is in.

c. MW8 (now OWDFMW-1) was not the only occurrence of dry massive basalt in the vicinity of the regional groundwater potentiometric surface. Please see response to comment 5.

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Reviewer: Maria Eloisa Q. Reyes, State of Hawaii Department of Health,
Hazard Evaluation and Emergency Response Office
Date: October 21, 2020

Item	Section No.	Comment
7	Section 10.1.7.1, Red Hill Regional Hydrology, Regional Groundwater Levels and Flow Direction	a. In the Phase II Remedial Investigation (RI), the triangulation technique was used to evaluate the basal groundwater flow direction beneath the OWDF. The anticipated direction of basal groundwater flow based upon regional tendencies was seaward or almost directly west for the OWDF, however, the gradient directly beneath the OWDF was found to be sloping to the northeast, roughly cross-gradient to the anticipated regional basal groundwater flow and towards the nearby PWC Pumping Station. <u>This confirms that the groundwater beneath the confined layers may behave in a compartmentalized way and that local groundwater flow patterns might not correspond to regional hydrodynamics.</u> b. It is inaccurate to state that the previous OWDF synoptic water level monitoring demonstrated groundwater flow to the Red Hill Shaft. The Red Hill Shaft lies east-southeast of the locations of the previous OWDF wells. The synoptic water level monitoring done as part of the 2001 OWDF investigation demonstrated that the groundwater gradient varied from northeast to east, so the flow vectors projected north of the Red Hill Shaft. This inferred direction is also consistent with the chloride concentration gradient that had been reported previously. c. The repeated reference to "very dry" massive basalts is misleading. Only MW8 (now OWDFMW-1) encountered a thick layer of massive basalt that appeared to confine the underlying groundwater.

Response:

a. Please see response to comment 6b. In complex, non-heterogeneous, and anisotropic geologic media such as is present at the OWDF, groundwater potentiometric surfaces can be used to estimate the hydraulic gradients, which may not precisely align with the groundwater flow directions. Moreover, we agree with this comment that localized variations in flow may occur; therefore, simple triangulation techniques based on three data points, though instructive, would not be expected to generate a precise representation of the transient hydraulic gradient field vector. In addition, please see the new Figure 11 (included in these responses to comments as Attachment C), which shows that the potentiometric gradients pointed roughly towards the supply well, though there were some variances that may be attributed to transient conditions related to pump cycling, as described in the response to comment 6b. In any case, the RI data summarized in WP Supplement Figure 8 (now Figure 10) showed a clear and rapid response in each of the three OWDF wells to changing pumping conditions. We agree that localized variations can occur (as stated in the WP), far more detailed data is proposed to be collected in this WP, and no final conclusions are being drawn regarding flow at the WP stage of this project.

b. Regarding the RI groundwater study, please see responses to comments 6b and 7a, as well as the new Figure 11 (showing flow gradients towards the supply well) (Attachment C), which all suggest that operation of the nearby supply well influences groundwater flow at the OWDF. This WP proposes gathering more data and conducting further analyses before drawing any final conclusions.

Although we draw no final conclusions before conducting the recommend work, the apparent chloride "gradient" might primarily reflect an elevated concentration of chloride in the vicinity of OWDFMW01 that might not be continuous with other nearby or regional conditions. In any case, no conclusions are being drawn at this point prior to gathering the additional data and conducting the analyses proposed in the WP. The proposed investigation will provide much more detailed data than is now available at the OWDF to evaluate any potential chloride concentration gradient in the vicinity of OWDFMW08 and elsewhere at the OWDF.

c. MW8 (now OWDFMW01) was not the only well that encountered a thick, dry layer of massive basalt that confined the underlying groundwater. See responses to comments 5 and 6c.

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Item	Section No.	Comment
8	Section 10.1.7.2, OWDF Hydrogeology	a. *Perched Groundwater:* WP Supplement Figure 2 shows that MW03 is in the northeast, not in the northwest boundary of the Stilling Basin. It is interesting that the perched water gradient indicated a direction directly up-ridge. b. *OWDF Basal Aquifer:* What is missing in this description of the groundwater gradient is that even with the Red Hill Shaft water supply pumps off, the vectors suggested a groundwater flow direction was to the northeast, not east or southeast, that would be required to flow to the Red Hill Shaft water supply pumps. This flow direction is consistent with the elevated chlorides on northwest side of the Facility. c. *General Chemistry of the Perched Water and the Basal Aquifer:* It has not been shown that the high chlorides in MW08 (now OWDFMW-1) are a result of saltwater intrusion in the generally accepted sense. In fact, the distance of this well from the coast argues strongly for some other mechanism to account for the high chlorides. The elevated TDS and pH persist in OWDFMW-1 to this day, 20 plus years from installation. The explanation that the well grout is the source of elevated pH does not seem valid since this condition has persisted for decades. Please review and include alternative explanations.

Response:

a. Text in Section 10.1.7.2 (4th paragraph, 3rd sentence) has been revised as follows:

> “Intervals of perched groundwater approximately 10 feet deep were consistently observed in MW02 and MW03, located on the northwest and northeast boundary of the Stilling Basin, respectively (WP Supplement, Figure 2).”

b. Comment acknowledged. Please see responses to comments 6a, 7a, and 7b, as well as the new Figure 11 (Attachment C) and existing Figure 8 (now Figure 10). The WP reflects the conclusion in the RI, backed by data, analyses, and multiple figures, that the basal aquifer beneath the OWDF is highly influenced by the nearby relatively large-capacity supply well. As shown in the new Figure 11 and discussed above in responses to other related comments, the simplified hydraulic gradient based on simple triangulation varied from northeast to east-southeast, which varies around and includes the direction towards the supply well. Variations in groundwater gradients during transient pumping conditions are not unusual.

c. We agree that there is no evidence of (or reason to suspect) saltwater intrusion in OWDFMW01; the following text (while true in a general sense) is therefore inapplicable and has been removed from Section 10.1.7.2, *General Chemistry of the Perched Water and the Basal Aquifer* subsection, 2nd paragraph:

> ~~“High concentrations of chloride and sodium in the basal aquifer have been documented to result from the influence of intruded seawater mixing in the Pearl Harbor aquifer system (Hufen, Eyre, and McConachie 1980).”~~

We agree that the elevated concentrations of chlorides, TDS, and pH are anomalous and will be evaluated as part of this investigation; findings will be presented in the Site Assessment Report after more data is gathered and analyzed.

Item	Section No.	Comment
9	Section 10.1.10.3, Ionic Chemistry of the Red Hill Monitoring Well Network	Please provide a clear description of how the upslope groundwater chemistry varies with depth. This data is available from the Red Hill investigation. The groundwater chemistry in the area of the OWDF is very different from that upslope and that expected in wells more than a mile from the coast. For example, the chloride concentration in OWDFMW-1 is about 1,000 mg/L and the pH is greater than 8, while the monitoring wells beneath the RHSF USTs have a chloride concentration of about 40 mg/L and a pH of 7 or less. Understanding the differences in groundwater chemistry, with depth, will provide insight into the groundwater flow and contaminant transport dynamics in the investigation area.

Response: We agree that the groundwater chemistry appears to exhibit differences in the vicinity of OWDFMW01 from what would be expected. Evaluating these conditions is one reason the WP proposes installing additional wells, gathering more data, and conducting further analysis of that data prior to making any final decisions or recommendations. Therefore, we suggest conducting the Site Assessment and performing additional groundwater analysis prior to performing detailed analyses of the groundwater chemistry. We acknowledge and will remain mindful of this comment, but no changes to the WP are recommended at this time.

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<table>
<tr><th>Item</th><th>Section No.</th><th>Comment</th></tr>
<tr><td>10</td><td>Section 10.2, Source, Receptor, and Exposure Assessment</td><td>The DOH disagrees with the Navy’s interpretation of the RHSF LTM data and investigations performed pursuant to the AOC, suggesting that there is a potential link between groundwater beneath the OWDF and the groundwater beneath Halawa Industrial Park. No data is provided to support this conclusion with any degree of certainty. Contamination identified in groundwater beneath the site is consistent with that anticipated from past site activities.</td></tr>
<tr><td colspan="3">Response: Comment acknowledged. No conclusions are being drawn at this time and we do not claim any certainty, with the exception that TPH detections in 2010-2013 could not have been related to the 2014 release, as discussed in response to comment 4. In addition, the WP acknowledges that the 2010-2015 groundwater exceedances may be related to former site activities. Nevertheless, it is not impossible for contamination from Halawa Industrial Park, if present, to migrate. This investigation proposes to evaluate these and other feasible possibilities, none of which are recommended to be ruled out at this time before installing wells and collecting data.</td></tr>
<tr><td>11</td><td>Section 14.3, Data</td><td>In addition to conducting an Electromagnetic Induction borehole survey, the use of an Optical and/or Acoustic televiewer is strongly recommended, to characterize bulk petrophysical properties, for the following reasons:
a. Borehole data collected from the Red Hill Phase II RI encountered weathered and fractured basalt beneath the OWDF area. Fractures can provide local migration pathways for fluids within the massive basalt formations.
b. It is also reasonable to suspect that interbedded weathered volcanic breccia and secondary formations have subjacent fluid-rich sections or pockets. Such sections would also be expected to be relatively fractured and grading downwards into the basal aquifer with increasing depth.</td></tr>
<tr><td colspan="3">Response: Comment acknowledged. However, based on our experience, the use of an optical or acoustic televiewer is not expected to yield actionable data or otherwise influence decision-making for this site. We believe that the substantial amount of other investigations proposed in this WP is a better use of available resources, and is more likely to produce data that can be used to assess the potential for risk and drive decision-making. No change to the WP is recommended at this time.</td></tr>
<tr><td>12</td><td>Section 14.6, Forensic Analyses, Evaluation, and TPH Fractions</td><td>Please include a discussion on how the Navy will distinguish between the RHSF tank wash disposed in the pit from the RHSF Release in 2014 and from fuel stored in the tanks in general.</td></tr>
<tr><td colspan="3">Response: As outlined in Section 14.6 of the WP, if TPH is detected, several methods will be used to evaluate the hydrocarbons that may be present. For example, any TPH detections will be subject to a “detailed review of the chromatograph pattern,” as recommended in the Technical Guidance Manual (TGM) § 9.3. Samples will also be analyzed for the full suite of volatile and semivolatile organic compounds, as well as tentatively identified compounds, which will include many of the potential biodegradation products or metabolites of fuel-related hydrocarbons and all of the target indicator compounds listed in TGM § 9.3.1.1. In addition, the listed methods would allow for a more detailed evaluation of petroleum carbon range analysis, including but not limited to the proposed use of Massachusetts Department of Environmental Protection (MADEP) methods, consistent with TGM § 9.3.1.2. All TPH detections will also be analyzed using silica gel cleanup to assess the relative fraction of polar material, which may be indicative of biodegradation byproducts, metabolites, or other carbon compounds; these results can be combined with the results of other analyses to attempt to determine the composition of the TPH. All of these analyses and results can be compared to available results from the OWDF RI and investigations conducted at the tank facility, as well as literature data and other reputable sources. Therefore, no changes to the WP are recommended at this time, but further analyses may be conducted after the WP is implemented, if warranted.</td></tr>
<tr><td>13</td><td>Section 17.2, Groundwater Sampling and Analysis, Natural Attenuation Parameters</td><td>a. Please include sulfates in the analysis.
b. Please clarify if lead scavengers are included in the analysis.
c. Please include per- and polyfluoroalkyl substances (PFAS) in the analysis if fire-fighting foam or other PFAS-containing chemicals were potentially released in the OWDF.</td></tr>
<tr><td colspan="3">Response:
a. Sulfates are included in the sampling and analysis plan (see WP Sections 10.2 and 14.4.4, and Worksheet 15).
b. Yes. Lead scavengers are included and will be analyzed by SW-846 8260 with other VOCs listed in Worksheet 15. Ethylene dibromide (EDB) was erroneously excluded from Worksheet 15 in the Draft WP. Both 1,2-dichloroethane and EDB are now listed in Worksheet 15. The EDB LOQ, LOD, and DL for groundwater are 1.0, 0.5, and 0.2 micrograms per liter, respectively. The EDB LOQ, LOD, and DL for soil are 0.005, 0.003, and 0.002 milligram per kilogram (mg/kg), respectively.
c. Please see responses to comments 2a and 2b. We did not identify any indication of PFAS use or disposal at the site.</td></tr>
</table>

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Item	Section No.	Comment
14	Section 17.4, Soil Sampling	a. Surface soil sampling and subsurface soil delineation of COPCs will be required during this field effort. The No Further Action letter that DOH issued in 2005 is no longer relevant/valid. Conclusions and recommendations made at that time were based on data collected using discrete samples. Our office now requires that Decision Unit-Multi Increment Sample (DU-MIS) data be collected and used for all final decision-making. Refer to Sections 3, 4, and 5 of the HEER Office *Technical Guidance Manual* (TGM) for information on the nature and implementation of DU-MIS investigations. DOH will not accept the use of discrete sample data for final decision-making as part of an environmental investigation. b. Please include lead in the analysis. c. Please include PFAS in the analysis if fire-fighting foam or other PFAS-containing chemicals were potentially released in the OWDF. Ensure that samples are collected, processed, and analyzed in accordance with the HEER TGM. This includes the need to test a minimum 10 grams of soil by the laboratory, unless otherwise agreed upon by the HEER Office.

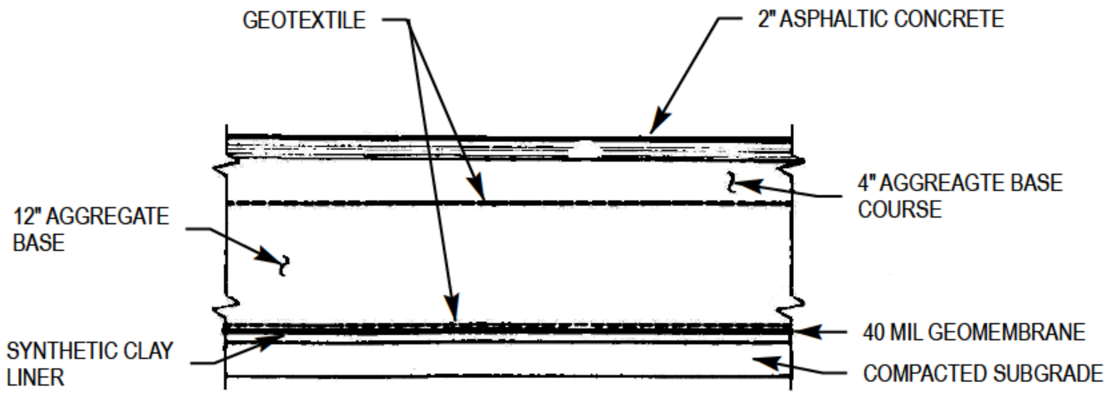
Response:

a. The Navy appreciates the DOH’s current preference for MIS sampling, agrees that it is often valuable, and typically incorporates MIS into most new investigations. However, the Navy respectfully but strongly disagrees with the statement that a historical NFA determination is categorically not “valid” or even “relevant” due to use of a sampling methodology reviewed and approved by DOH at the time. This is especially true at sites like the OWDF, which underwent an extensive two-phase RI, a Removal Action, and additional analyses after the Phase II RI, all of which was conducted under a DOH-reviewed and -approved WP and addressed every comment DOH provided during the process. At no time during these historical activities did DOH submit any comment suggesting MIS sampling. We are unaware of any precedent in any statute, regulation, or the guidance in the TGM or elsewhere that suggests historical NFA determinations are now invalid or irrelevant because DOH later developed its recommendations for MIS sampling. Changes in recommended sampling practice methodologies that occur later cannot negate valid and detailed investigations and determinations. Therefore, we do not recommend additional soil sampling beyond that proposed in the WP.

b. Lead is not considered a soil COPC based on the results and findings of the RI reports and RVR. Over 180 soil samples were analyzed for both lead and organolead during the Phase I RI. No organolead was detected in any sample. Three soil samples had total lead concentrations that exceeded the DOH Recommended Cleanup Levels of 400 mg/kg, but all three detections were below the EPA PRG (1,000 mg/kg) used at the time. The maximum site concentration of lead in soil of all site samples analyzed was 512 mg/kg and average surface and subsurface total lead concentrations for each EAOC were below the DOH Recommended Cleanup Level the cited in the RI (400 mg/kg). Additionally, confirmation samples taken beneath the Stilling Basin during the removal action did not have any lead concentrations exceeding the cleanup criteria. The majority of the lead detections likely represent background concentrations (surface and subsurface soil 95th percentile background levels for Koolau volcanic soils are 27 and 100 mg/kg, respectively [*Environmental Background Analysis of Metals in Soil at Navy Oahu Facilities, Oahu, Hawaii* (DON 2006)]), which is consistent with HEER’s background threshold lead value of 72.8 mg/kg (DOH 2012). Importantly, lead was also not detected in any of the five groundwater samples analyzed during the Phase I RI, in which the more-impacted perched water located directly below the Stilling Basin and throughout the site was sampled.

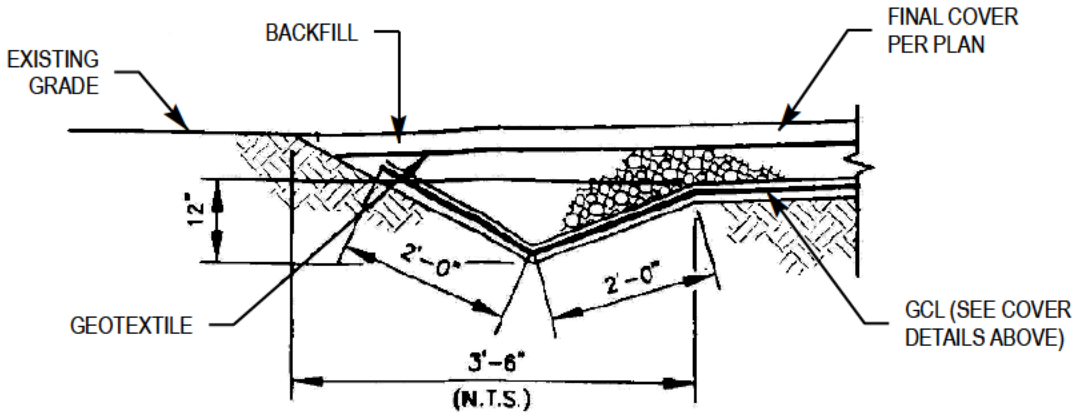
c. Please see responses to comments 2a and 2b: we did not find any records or other indications of the use of firefighting foam or other PFAS-containing chemicals at the OWDF.

Attachment A:
Figure 3



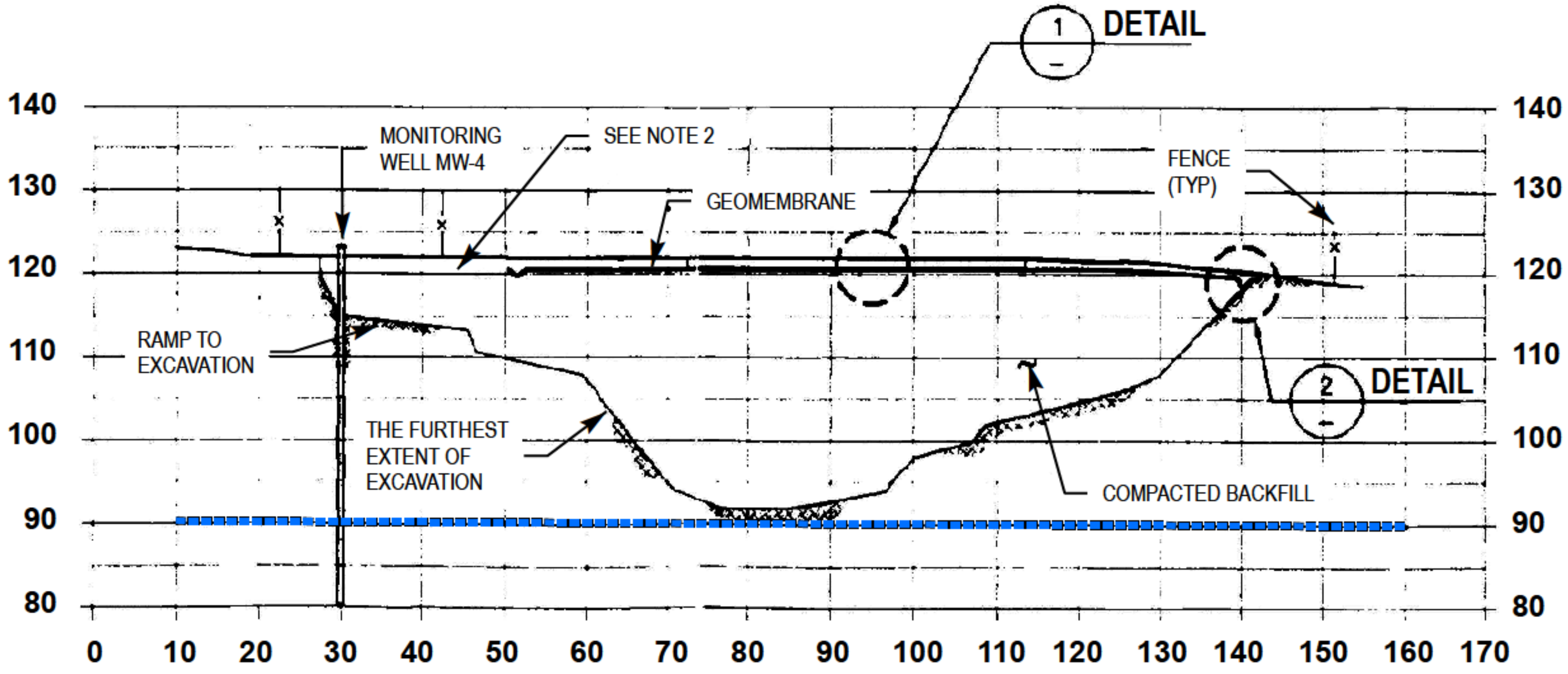
1 – DETAIL

SCALE: 3/4" = 1' – 0"



2 – ANCHOR TRENCH DETAIL

SCALE: 1/2" = 1' – 0"



A SECTION

4-1, 7-1

VERT. = 1:20'

HORIZ. = 1:20'

LEGEND

▪▪▪▪▪ Approximate Perched Groundwater Level

NOTES

1. Drawing modified from the Final Remediation Verification Report, Figure 7-2: Typical Section Closure of Red Hill Stilling Basin, Oahu, Hawaii (DON 1996).
2. The liner was extended over the entire plan of the excavation with exception of ramp which was constructed outside of the excavation limit.

Figure 3
Cross-Section of Stilling Basin
after Removal Action
Site Assessment WP
Red Hill Oily Waste Disposal Facility
JBPHH, Oahu, Hawaii

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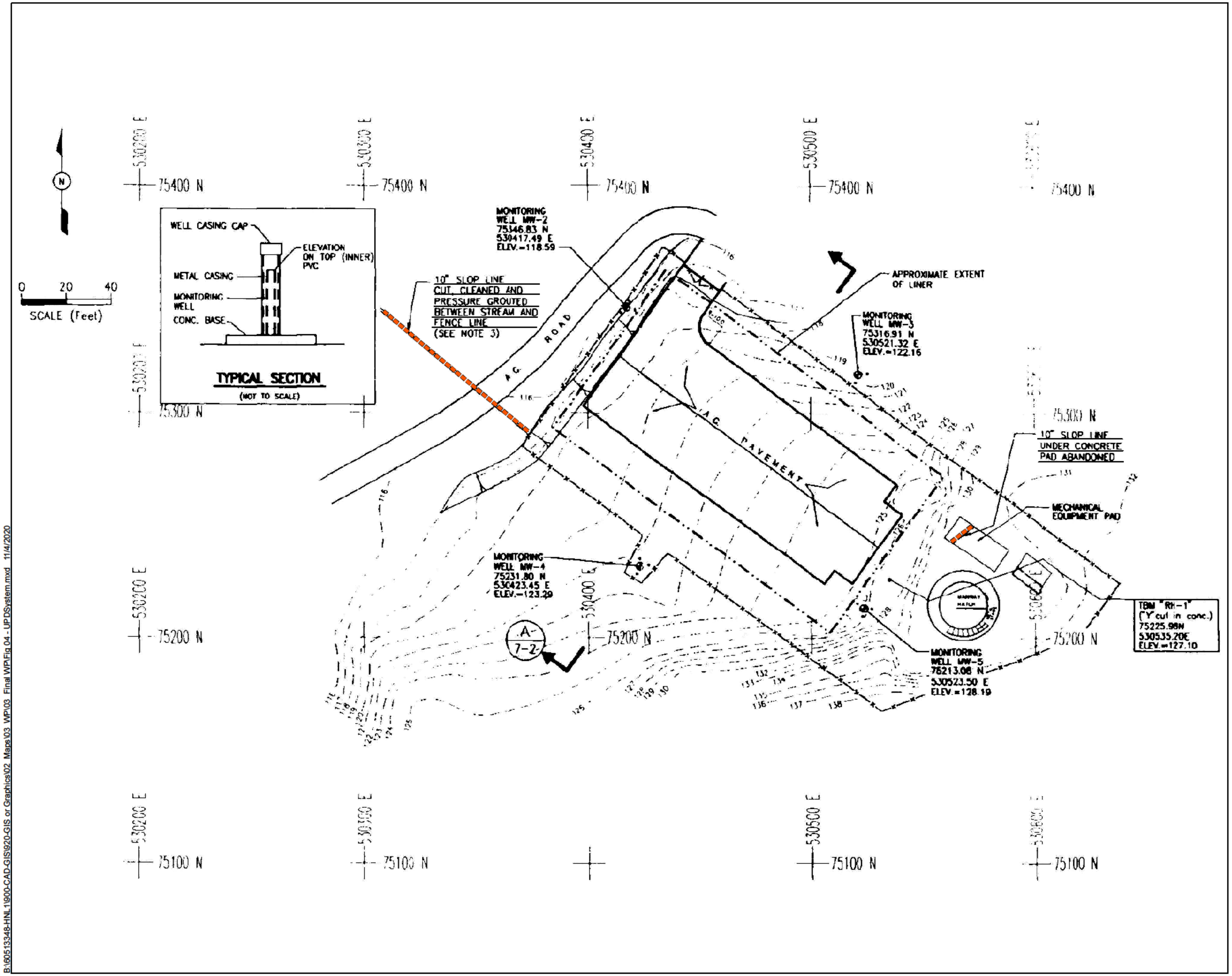
Attachment B:
Figure 4



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LEGEND

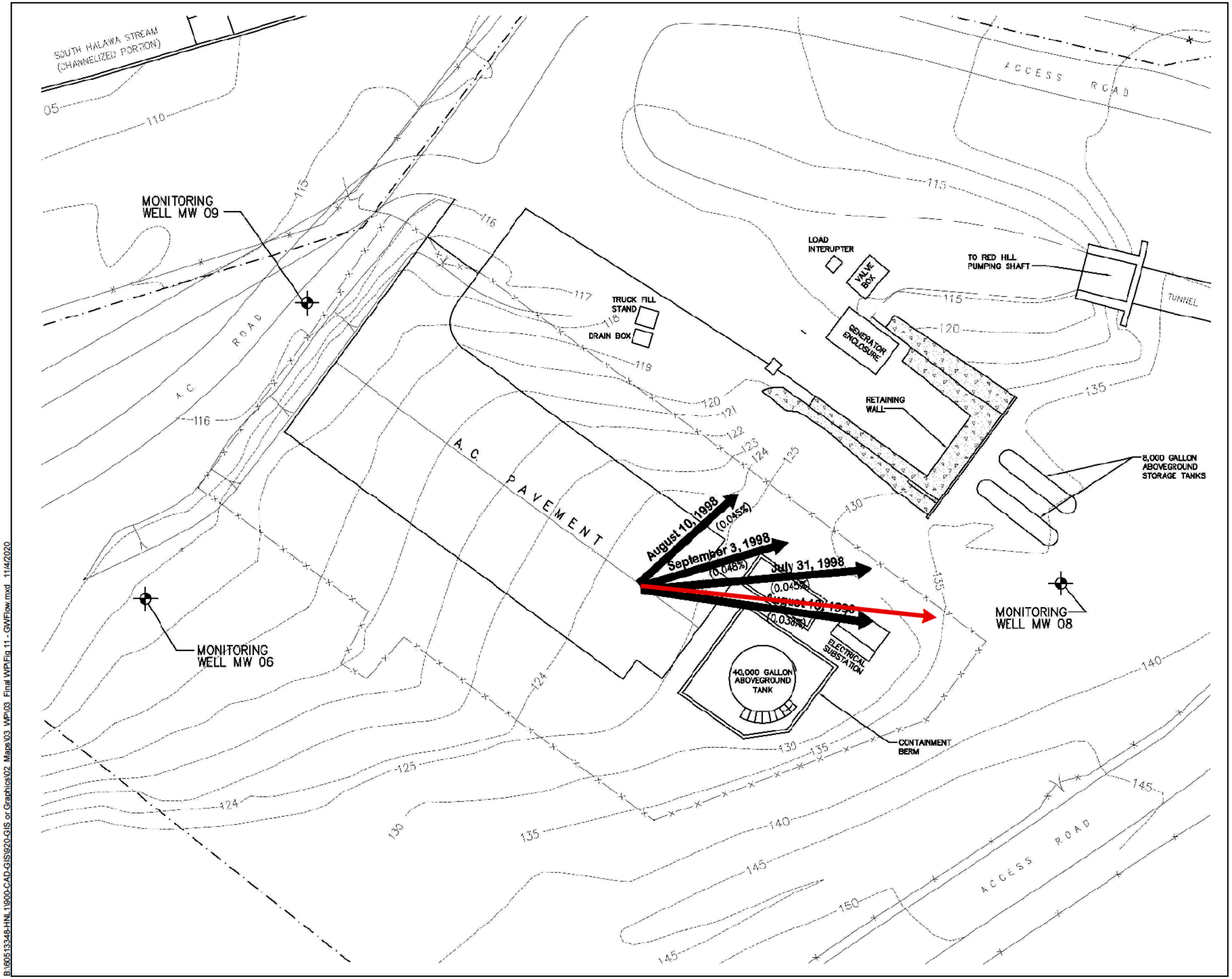
▬ Pipe Abandoned In Place

NOTES

1. Drawing modified from the Final Remediation Verification Report, Figure 7-1: Final Grade (As Built) Closure of Red Hill Stilling Basin, Oahu, Hawaii (DON 1996).
2. Coordinates referred to the Hawaii State Plane Coordinate Grid System, Zone 3.
3. Pipe has been grouted with 2 sack concrete slurry.

Figure 4
Underground Piping and Delivery System
Abandoned in Place during the
1995 Removal Action
Site Assessment WP
Red Hill Oily Waste Disposal Facility
JBPHH, Oahu, Hawaii

Attachment C:
Figure 11



LEGEND

🟥→	Direction of Red Hill Shaft Pump
— · — · —	Property Line
—x—x—x—	Chain Link Fence
- - - -130- - - -	Elevation Contour (Feet, msl)
August 18, 1998 ➡ (0.038%)	Calculated Groundwater Flow Direction Based on Water Level Observations (Gradient in Percentage, Feet Change in Groundwater Head / Distance)
⌖	Basal Aquifer Monitoring Well

NOTES

1. Drawing modified from the Phase II Remedial Investigation Report, Figure 3-7: Estimated Direction of Basal Groundwater Flow (DON 2000).

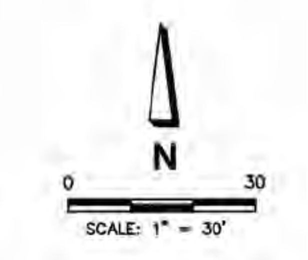


Figure 11
Estimated Direction of
Basal Groundwater Flow
Site Assessment WP
Red Hill Oily Waste Disposal Facility
JBPHH, Oahu, Hawaii

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