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SAMPLING AND ANALYSIS PLAN (FIELD SAMPLING PLAN AND QUALITY ASSURANCE PROJECT PLAN) MUNITIONS CONSTITUENTS REMEDIAL INVESTIGATION SITE 12 EOD AREA NAS BRUNSWICK ME

10/1/2012

TETRA TECH

Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) Munitions Constituents Remedial Investigation of Site 12 EOD Area

Former Naval Air Station Brunswick

Brunswick, Maine

Naval Facilities Engineering Command Mid-Atlantic

Contract Number N62472-03-D-0057
Contract Task Order 69

October 2012

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

FINAL

SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)
October 2012

MUNITIONS CONSTITUENTS REMEDIAL INVESTIGATION OF SITE 12 EOD AREA
FORMER NAVAL AIR STATION BRUNSWICK, MAINE

Prepared for:
Naval Facilities Engineering Command Mid-Atlantic
BRAC PMO Northeast
4911 South Broad Street
Philadelphia, PA 19112-1303

Prepared by:
Tetra Tech
661 Andersen Drive
Pittsburgh, Pennsylvania 15220-2745
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Prepared under:
Comprehensive Long-Term Environmental Action Navy
Contract No. N62472-03-D-0057
Contract Task Order 69

Review Signatures:	10-2-12 Tom Johnston Tetra Tech Quality Assurance Manager	Linda Klink, P.E. Tetra Tech Project Manager
Approval Signatures:	10-2-12 Todd Bober Navy BRAC PMO NE Remedial Project Manager	See Attached Janice Nielsen NAVFAC QAO/Chemist QAO/Chemist

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

SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)
April 2012

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Approval Signatures:

Todd Bober Navy BRAC PMO NE Remedial Project Manager	Janice Nielsen NAVFAC QAO/Chemist QAO/Chemist

EXECUTIVE SUMMARY

Tetra Tech, Inc. has prepared this Sampling and Analysis Plan (SAP) that encompasses Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) requirements for the Remedial Investigation (RI) of Site 12 Explosive Ordnance Disposal (EOD) Area at the former Naval Air Station (NAS) Brunswick, Maine, under Contract Task Order (CTO) 69, Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract N62472-03-D-0057.

This SAP was generated for and complies with applicable United States Department of the Navy, United States Environmental Protection Agency (USEPA) Region I, and Maine Department of Environmental Protection (MEDEP) requirements, regulations, guidance, and technical standards. This includes the Department of Defense (DoD), Department of Energy (DOE), and USEPA Intergovernmental Data Quality Task Force (IDQTF) environmental requirements regarding federal facilities. This SAP is presented in the format of standard worksheets specified in the Uniform Federal Policy Quality Assurance Project Plans (UFP-QAPP) guidance documents (IDQTF, 2005).

This SAP outlines the organization, project management, objectives, planned activities, measurement, data acquisition, assessment, oversight, and data review procedures associated with the planned investigations at Site 12. Protocols for sample collection, handling and storage, chain of custody, laboratory and field analyses, data validation, and reporting are also addressed in this SAP.

Site 12 EOD Area is located in the southeastern portion of former NAS Brunswick in a remote, open, upland area on Buttermilk Mountain, almost 1 mile southeast of Building 539 in the Weapons Compound. Site 12 has been used for the disposal of ordnance, pyrotechnics, privately manufactured explosive devices, and war souvenirs. On June 1, 2004, EOD activities at NAS Brunswick were officially terminated.

To facilitate a more effective evaluation and because of the mixed history of Site 12 (multiple berms to contain explosive detonations), it was divided into six decision units (DUs). DU1 through DU6, based on historical site operations, sample media (in the case of groundwater), potential contamination levels, and potential remedial objectives. A Site Inspection (SI) was conducted in 2008 that identified material potentially presenting an explosive hazard (MPPEH) on site and a large number of subsurface anomalies located in the central berm area. In 2010 and 2011, a time-critical removal action (TCRA) was conducted that cleared the surface of MEC/MPPEH items and identified both MPPEH and construction debris in the subsurface through limited trenching activities within the central berm area. Several MEC/MPPEH items were identified within the perimeter road, with the highest density of MEC/MPPEH items located in the

central berm, as expected, and a small number of kick-outs and suspected training aids located in the outer area of the site.

The primary objective of the Site 12 RI is to provide sufficient data to identify areas that are either contaminated or non-contaminated. Those areas that are identified as non-contaminated would be removed from the Site 12 CSM and potentially available for transfer. A secondary sampling objective would be to calculate ecological and human health risk for each DU.

While this document was in regulatory review a decision was made by the stakeholders to extract select Navy-approved sections related to the installation of the planned monitoring wells, and supporting geophysical surveying, in an effort to keep moving the project forward. Conditional approval was granted by the USEPA and MEDEP in July 2012 to conduct field work on the groundwater monitoring well portion of the RI scope. The desktop fracture trace survey was completed in July, 2012 and monitoring well installation was completed in August 2012, in accordance with the approved Work Plan and the subject *"Draft Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) for Munitions Constituents Remedial Investigation of Site 12 EOD Area, former Naval Air Station Brunswick, Maine"*, dated May 2012 ("the Site 12 SAP").

The Work Plan (Tetra Tech, 2012a) for the groundwater Investigation, dated August 9, 2012, included the following scope items.

Geophysical Investigation

- desktop fracture trace survey,
- very low frequency [VLF] geophysical survey
- electromagnetic geophysical survey

Monitoring Well Installation

- borehole installation, logging, and lithology sampling,
- monitoring well installation, surveying, development, and sampling

During the review of Work Plan and implementation of the fracture trace survey, changes from the time the draft SAP was issued include the following

- Addition of a staff gauge at the Site 12 pond.

- Deferred decision on need for geophysical surveys specifically the very low frequency (VLF) and ground penetrating radar (GPR) assessments pending evaluation of the groundwater analytical data by the stakeholders. If required, a VLF and survey will be performed to locate water-bearing fractures in the deeper fractured bedrock. If required, GPR geophysical surveys will be performed in the vicinity of each monitoring well to locate the depth to groundwater, the top of bedrock, and sub-horizontal water-bearing fractures. The geophysical results will be discussed with technical stakeholders.

- Moved westernmost monitoring well 25 feet further to the west, as shown in Figure 1 of the Groundwater Investigation Work Plan (Tetra Tech, 2012a).

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17-1 DU1 (Existing Berm Mound) ISM Sample Location Map
17-2A DU2A, 2B, 2C, and 2D (Localized Berm Areas) ISM Soil Sample Location Map
17-2B DU2F (Non-Berm Areas) ISM Soil Sample Location Map
17-2C DU2A, 2B, 2C, 2D and 2E (Localized Berm Areas) Discrete Soil Sample Location Map
17-3 DU3A (Intermediate Area-Inner), DU3B (Intermediate Area – Outer), and DU4 (Outer Area) ISM Surface Soil Sample Location Map
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LIST OF APPENDICES

A – Site-Specific Field Standard Operating Procedures
B – Project Screening Level Support Documentation
C – Laboratory DoD ELAP Certification/Maine Certification
D – Human Health Risk Assessment Methodology
E – Ecological Risk Assessment Methodology
F – Historical Information

ACRONYMS AND ABBREVIATIONS

AES	Atomic Emission Spectroscopy
ALS	Analytical Laboratory Services, Inc.
BASCE	Brunswick Area Citizens for a Safe Environment
BFB	Bromofluorobenzene
bgs	Below Ground Surface
BNAS	Brunswick Naval Air Station
BRAC	Base Realignment and Closure
°C	Degree Celsius
CA	Corrective Action
CAS	Chemical Abstract Service
CCC	Calibration Check Compound
CCME	Canadian Council and Ministers of the Environment
CCV	Continuing Calibration Verification
CFR	Code of Federal Regulations
CG	Certified Geologist
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CTO	Contract Task Order
CVAA	Cold Vapor Atomic Absorption
%D	Percent Drift or Percent Difference
DBCP	1,2-Dibromo-3-Chloropropane
DDESB	Department Of Defense Explosives Safety Board
DFTPP	Decafluorotriphenylphosphine
DGPS	Digital Global Positioning System
DL	Detection Limit
DO	dissolved oxygen
DoD	Department of Defense
DOE	Department of Energy
DOP	Dilution of Precision
DOT	Department of Transportation
DPT	Direct-Push technology
DQI	Data Quality Indicator

DQO	Data Quality Objective
DU	Decision Unit
DVM	Data Validation Manager
ECD	Electron Capture Detector
Eco SSL	Ecological Soil Screening Level
EDB	Ethylene Dibromide
EDD	Electronic Data Deliverable
ELAP	Environmental Laboratory Approval Program
EM	Electromagnetic
EOD	Explosive Ordnance Disposal
EPH	Extractable Petroleum Hydrocarbons
ERA	Ecological Risk Assessment
ESL	Ecological Screening Level
ESS	Explosive Safety Submission
°F	Degree Fahrenheit
FD	Field Duplicate
FID	Flame Ionization Detector
FOL	Field Operations Leader
FS	Feasibility Study
FSP	Field Sampling Plan
FTMR	Field Task Modification Request
FY	Fiscal Year
GC	Gas Chromatography
GPS	global positioning system
GPR	Ground Penetrating Radar
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HCl	Hydrochloric Acid
HDOP	Horizontal Dilution of Precision
HE	High Explosive
HHRA	Human Health Risk Assessment
HI	Hazard Index
HMX	Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine/His/Her Majesty's Explosive
HNO_3	Nitric Acid
HPLC	High-Pressure Liquid Chromatography
HSM	Health and Safety Manager

IBD	Inhabited Building Distance
ICAL	Initial Calibration
ICP	Inductively Coupled Plasma
ICS	Interference Check Standard
ICV	Initial Calibration Verification
IDQTF	Intergovernmental Data Quality Task Force
IDW	Investigation-Derived Waste
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	Incremental Lifetime Cancer Risk
IS	Internal Standard
ISM	Incremental Sampling Methodology
ITRC	Interstate Technology Regulatory Council
JATO	Jet Assisted Take Off
Katahdin	Katahdin Analytical Services, Inc.
LANL	Los Alamos National Laboratory
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LIMS	Laboratory Information Management System
LOD	Limit of Detection
LODV	Limit of Detection Verification
LOQ	Limit of Quantitation
LUC	Land Use Control
MEC	Munitions and Explosives of Concern
MEDEP	Maine Department of Environmental Protection
MCL	Maximum Contaminant Level
MDAS	Munitions Documented As Safe
MDL	Method Detection Limit
MEDEP	Maine Department of Environmental Protection
MCT	Matrix Conductivity Threshold
mg/kg	Milligram Per Kilogram
MPC	Measurement Performance Criterion
MPPEH	Material Potentially Presenting an Explosive Hazard
MRP	Munitions Response Program
MRRA	Midcoast Regional Redevelopment Authority
MS	Matrix Spike or Mass Spectrometry
MSD	Matrix Spike Duplicate

NA	Not Applicable
NAD	North American Datum
NAS	Naval Air Station
NAVD	North American Vertical Datum
NAVFAC	Naval Facilities Engineering Command
NE	Northeast
NEDD	NIRIS Electronic Data Deliverable
NG	Nitroglycerin
NIRIS	Naval Installation Restoration Information Solution
NTU	nephelometric turbidity unit
ORNL	Oak Ridge National Laboratory
ORP	oxidation-deduction potential
OSHA	Occupational Safety and Health Administration
oz	Ounce
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PDF	Portable Document File
PETN	Pentaerythritol tetranitrate
PID	Photoionization Detector
PM	Project Manager
PMO NE	Project Management Office Northeast
POC	Point Of Contact
PPE	Personal Protective Equipment
PQLG	Project Quantitation Limit Goal
PQO	Project Quality Objective
PSL	Project Screening Level
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QC	Quality Control
QSM	Quality Systems Manual
r	Linear Regression Correlation Coefficient
%R	Percent Recovery
RAG	Remedial Action Guideline
RDX	Octahydro-1,3,5,7-Tetranitro-1,3,5-Triazine/Royal Demolition Explosive

RF	Response Factor
RI	Remedial Investigation
ROD	Record of Decision
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RRT	Relative Retention Time
%RSD	Percent Relative Standard Deviation
RSD	Relative Standard Deviation
RT	Retention Time
SAP	Sampling and Analysis Plan
SCAR	Sub-Caliber Aircraft Rocket
SDG	Sample Delivery Group
SDZ	Surface Danger Zone
SI	Site Inspection
SIM	Selected Ion Monitoring
SOP	Standard Operating Procedure
SPCC	System Performance Check Compound
SQL	Structured Query Language
SSL	Soil Screening Level
SSO	Site Safety Officer
SU	Sampling Unit
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TBD	To Be Determined
TCLP	Toxicity Characteristic Leaching Procedure
TCRA	Time Critical Removal Action
Tetryl	Methyl-2,4,6-Trinitrophenylnitramine
TNT	2,4,6-Trinitrotoluene
TP	Technical Paper
TRW	Technical Review Workgroup
UFP-SAP	Uniform Federal Policy for Sampling Analysis Plan
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
µg/dL	Microgram per Deciliter
µg/L	microgram per liter
USCS	Unified Soil Classification System

USEPA	United States Environmental Protection Agency
UV	Ultraviolet
UXO	Unexploded Ordnance
VLF	Very Low Frequency
VPH	Volatile Petroleum Hydrocarbon
VOC	Volatile Organic Compound

SAP Worksheet #2 -- SAP Identifying Information

(UFP-QAPP Manual Section 2.2.4)

Site Name/Number: Site 12 EOD Area
Contractor Name: Tetra Tech, Inc.
Contract Number: N62472-03-D-0057
Contract Title: Comprehensive Long-Term Environmental Action Navy (CLEAN)
Work Assignment Number: Contract Task Order (CTO) 69

1. This Sampling and Analysis Plan (SAP) was prepared in accordance with the requirements of the Intergovernmental Data Quality Task Force (IDQTF) document, *Uniform Federal Policy for Quality Assurance Plans* (UFP-QAPP) (2005) and the United States Environmental Protection Agency (USEPA) document, *Guidance for Quality Assurance Project Plans, QA/G-5* (2002).

2. Identify regulatory program: The Department of Defense (DoD) Munitions Response Program (MRP), the processes established by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), the Maine Department of Environmental Protection (MEDEP), and related state laws and rules, and consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP)..

3. This SAP is a project-specific SAP.

4. List dates of scoping sessions that were held:

Scoping Session	Date
NAS Brunswick Technical Meeting and site Visit	December 6 - 7, 2011

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

Title	Date
NA	

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

MEDEP (regulatory stakeholder)
U.S. EPA Region 1 (regulatory stakeholder)
U.S. Navy (property owner)
Brunswick Area Citizens for a Safe Environment (BACSE)
Midcoast Regional Redevelopment Authority (MRRA)

7. Lead organization: Navy, Base Realignment and Closure (BRAC) Program Management Office Northeast (PMO NE)

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

Not applicable (NA) because there are no exclusions.

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

Not applicable (NA), as there are no exclusions.

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
A. Project Management		
Documentation		
1	Title and Approval Page	NA
2	SAP Identifying Information	NA
3	Distribution List	NA
4	Project Personnel Sign-Off Sheet	NA
Project Organization		
5	Project Organizational Chart	NA
6	Communication Pathways	NA
7	Personnel Responsibilities and Qualifications Table	NA
8	Special Personnel Training Requirements Table	NA
Project Planning/Problem Definition		
9	Project Scoping Session Participants Sheet	NA
10	Conceptual Site Model	NA
11	Data Quality Objectives	NA
12	Measurement Performance Criteria Table – Field Quality Control Samples	NA
13	Secondary Data Criteria and Limitations Table	NA
14	Summary of Project Tasks	NA
15	Reference Limits and Evaluation Table	NA
16	Project Schedule/Timeline Table	NA
B. Measurement Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	NA
18	Sampling Locations and Methods/Standard Operating Procedure (SOP) Requirements Table	NA
19	Analytical Methods/SOP Requirements Table	NA
20	Field Quality Control (QC) Sample Summary Table – Analytical Samples	NA
21	Project Sampling SOP References Table	NA
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	NA

UFP-QAPP Worksheet #	Required Information	Crosswalk to Related Information
Analytical Tasks		
23	Analytical SOP References Table	NA
24	Analytical Instrument Calibration Table	NA
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	NA
Sample Collection		
26	Sample Handling System	NA
27	Sample Custody Requirements Table	NA
Quality Control Samples		
28	Laboratory QC Samples Table	NA
Data Management Tasks		
29	Project Documents and Records Table	NA
30	Analytical Services Table	NA
C. Assessment Oversight		
31	Planned Project Assessments Table	NA
32	Assessment Findings and Corrective Action Responses Table	NA
33	Quality Assurance (QA) Management Reports Table	NA
D. Data Review		
34	Verification (Step I) Process Table	NA
35	Validation (Steps IIa and IIb) Process Table	NA
36	Analytical Data Validation (Steps IIa and IIb) Summary Table	NA
37	Usability Assessment	NA

SAP Worksheet #3 -- Distribution List

(UFP-QAPP Manual Section 2.3.1)

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Driller To Be Determined (TBD) (electronic copy only)	Drilling Subcontractor/ Provides drilling services	TBD	TBD	TBD
Surveyor (TBD) (electronic copy only)	Surveying Subcontractor/ Provides surveying services	TBD	TBD	TBD

SAP Worksheet #4 -- Project Personnel Sign-Off Sheet

(UFP-QAPP Manual Section 2.3.2)

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

1. In the case of regulatory agency personnel with oversight authority, approval letters or e-mails will constitute verification that applicable sections of the SAP have been reviewed. Copies of regulatory agency approval letters/e-mails will be retained in the project files and are listed in Worksheet #29 as project records.

2. E-mails will be sent to the Navy, Tetra Tech, and subcontractor project personnel requesting that they verify by e-mail that they have read the applicable SAP/sections and the date on which they were reviewed. Copies of the verification e-mail will be included in the project files and are identified in Worksheet #29.

   Copies of the signed Worksheets #s1 and 4 will be retained in the project files and are identified as project documents in Worksheet #29.

Name[1]	Organization/Title/Role	Telephone Number	Signature/E-Mail Receipt	SAP Section Reviewed	Date SAP Read
Navy and Regulator Project Team Personnel					
Todd Bober	Navy RPM/Manages Project activities for Navy	215-897-4911	See Worksheet #1, Title and Approval Page	All	
Janice Nielsen	NAVFAC QAO/Chemist/ Reviews SAP and quality assurance documentation for Navy	757-322-8339	See Worksheet #1, Title and Approval Page	All	
Tetra Tech Project Team Personnel					
Linda Klink	Tetra Tech PM	412-921-8650	See Worksheet #1, Title and Approval Page	All	
Matt Soltis	Tetra Tech HSM	412-921-8912	See HASP signature page	HASP	
Ralph Brooks	Tetra Tech UXO Manager	770-413-0965		All	

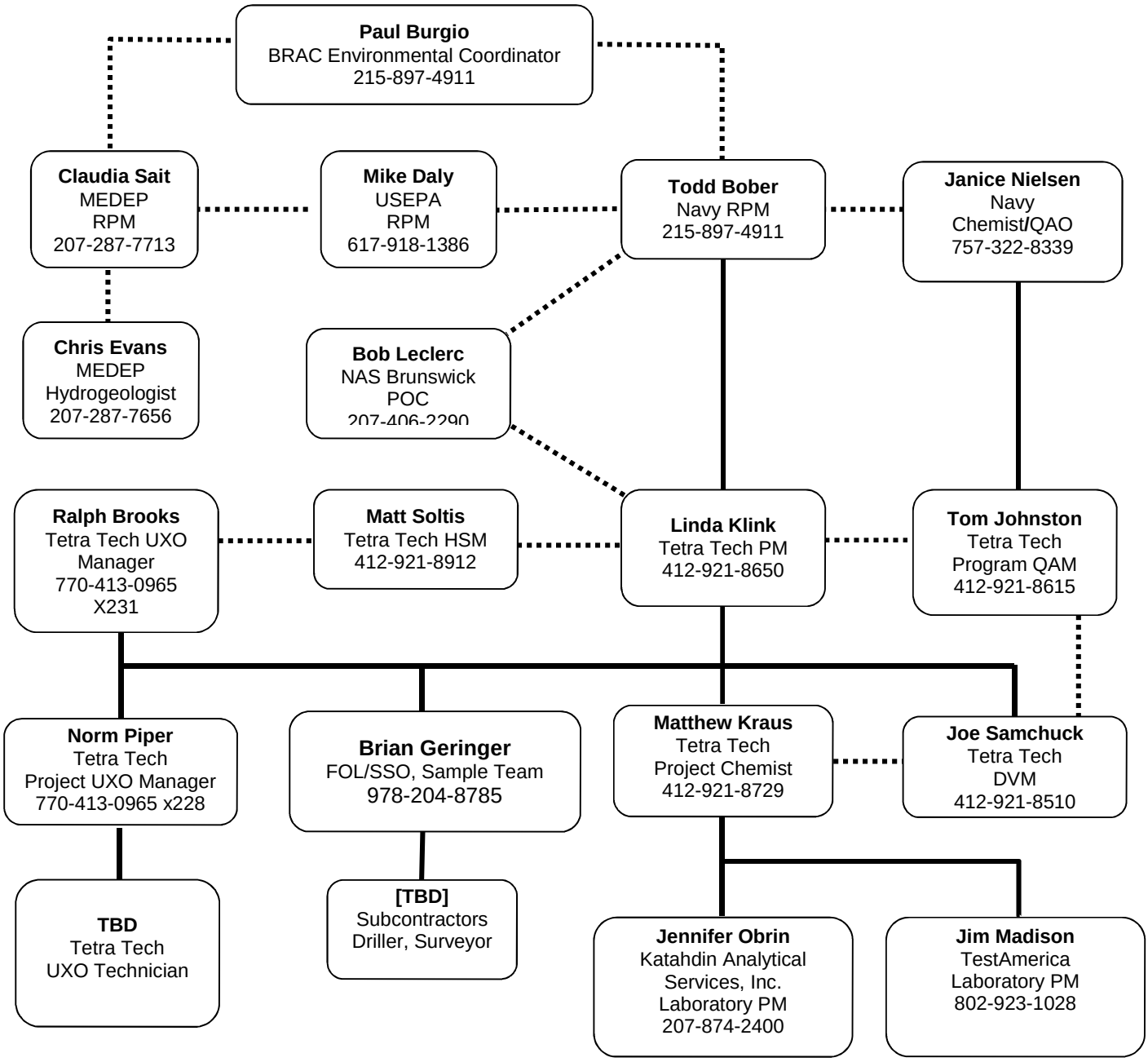
Name[1]	Organization/Title/Role	Telephone Number	Signature/E-Mail Receipt	SAP Section Reviewed	Date SAP Read
Tim Evans	Tetra Tech Maine CG	412-921-7281	See Worksheet #1, Title and Approval Page	All	
Brian Geringer	Tetra Tech/FOL/SSO/ Manages field operation and site safety issues	978-204-8785	See Field Forms – Munitions Response Program (MRP) FF.1 - SAP Worksheet #4 (Field Personnel) to be signed in the field	All	
Tom Johnston, PhD	Tetra Tech/ QAM/Manages Corporate QA Program and implementation	412-921-8615	See Worksheet #1, Title and Approval Page	All	
Mathew Kraus	Tetra Tech/Project Chemist/ Provides coordination with laboratory	412-921-8729		All	
Joe Samchuck	Tetra Tech/DVM/Manages data validation	412-921-8510		Worksheet #s12, 14, 15, 19, 20, 23-28, 30, and 34-37	
James Coffman	Tetra Tech Project Geophysicist	412-921-8244		Geophysical Worksheets	
Subcontractor Personnel					
Jennifer Obrin	Katahdin/ Laboratory PM/ Representative for Laboratory and Analytical Issues	207-874-2400 x 17		Worksheet #s 6, 12, 14, 15, 19, 23-28, 30, and 34-37	
Jim Madison	TestAmerica/Laboratory PM/ Representative for Laboratory and Analytical Issues	802-923-1028		Worksheet #s 6, 12, 14, 15, 19, 23-28, 30, and 34-36	
Driller (TBD)	Drilling Subcontractor PM/ Provides Drilling Services	TBD		Worksheet #s 6, 14, 17, and figures	
Surveyor (TBD)	Surveying PM/ Provides Surveying Services	TBD		Worksheet #s 6, 14, 17, and figures	

1 Persons listed on this worksheet will be responsible for distributing the SAP to the appropriate people within their organization.

SAP Worksheet #5 -- Project Organizational Chart

(UFP-QAPP Manual Section 2.4.1)

Lines of Authority → Lines of Communication ⋯



SAP Worksheet #6 -- Communication Pathways

(UFP-QAPP Manual Section 2.4.2)

Communication Driver	Responsible Affiliation	Name	Phone Number and/or E-Mail	Procedure
Field Progress Notifications	Tetra Tech FOL/SSO Tetra Tech PM Navy RPM USEPA MEDEP	Brian Geringer Linda Klink Todd Bober Mike Daly Claudia Sait	978-204-8785 412-921-8650 215-897-4911 617-918-1384 207-287-7713	The Tetra Tech FOL will verbally or via e-mail inform the Tetra Tech PM daily on the project field work schedule, findings, and issues. The Tetra Tech PM will send project updates to the Project Team via e-mail, at a minimum on a weekly basis at the end of each work shift. Additional updates will be made, as needed to inform the team of issues and findings, as described below.
SAP amendments	Tetra Tech FOL/SSO Tetra Tech PM Navy RPM USEPA MEDEP	Brian Geringer Linda Klink Todd Bober Mike Daly Claudia Sait	978-204-8785412-921-8650 215-897-4911 617-918-1384 207-287-7713	The Tetra Tech FOL will verbally inform the Tetra Tech PM within 24 hours of realizing a need for an amendment. The Tetra Tech PM will document the proposed changes via a Field Task Modification Request (FTMR) form and send the Navy RPM a concurrence letter within 2 days of identifying the need for change, if necessary. SAP amendments will be submitted by the Tetra Tech PM to the Navy RPM for review and approval. SAP amendments will be submitted by the Tetra Tech PM to the USEPA and MEDEP for review and approval.

Communication Driver	Responsible Affiliation	Name	Phone Number and/or E-Mail	Procedure
				The Tetra Tech PM will send scope changes to the Project Team via e-mail within 1 business day. The RPM or designee will inform the Project Team via e-mail within 7 business days.
Changes in field work schedule	Tetra Tech PM Navy RPM USEPA MEDEP	Linda Klink Todd Bober Mike Daly Claudia Sait Paul Burgio	412-921-8650 215-897-4911 617-918-1384 207-287-7713 215-897-4903	The Tetra Tech PM will verbally inform the Navy RPM on the day that a schedule change is known. The RPM or designee will inform the Project Team via e-mail within 2 business days.
Issues in the field that result in changes in scope of field work	Tetra Tech FOL/SSO Tetra Tech PM Navy RPM USEPA MEDEP	Brian Geringer Linda Klink Todd Bober Mike Daly Claudia Sait	978-204-8785 412-921-8650 215-897-4911 617-918-1384 207-287-7713	The Tetra Tech FOL will verbally inform the Tetra Tech PM on the day that the issue is discovered. The Tetra Tech PM will inform the Navy RPM (verbally or via e-mail) within 1 business day of discovery. The Navy RPM will issue a scope change (verbally or via e-mail), if warranted. The scope change is to be implemented before further work is executed. The Tetra Tech PM will document the change via an FTMR form within 2 days of identifying the need for change and will obtain required approvals within 5 days of initiating the form.

Communication Driver	Responsible Affiliation	Name	Phone Number and/or E-Mail	Procedure
				The RPM or designee will inform the Project Team via e-mail within 2 business days.
Recommendations to stop work and initiate work upon corrective action	Tetra Tech FOL/SSO Tetra Tech PM Tetra Tech QAM Tetra Tech Project Chemist Tetra Tech HSM Navy RPM	Brian Geringer Linda Klink Tom Johnston Matt Kraus Matt Soltis Todd Bober	978-204-8785 412-921-8650 412-921-8615 412-921-8729 412-921-8912 215-897-4911	If Tetra Tech is the responsible party for a stop- work command, the Tetra Tech FOL will inform on-site personnel, subcontractor(s), and the identified Project Team members within 1 hour (verbally or by e-mail). If a subcontractor is the responsible party, the subcontractor PM must inform the Tetra Tech FOL within 15 minutes, and the Tetra Tech FOL will then follow the procedure listed above.
Corrective action (CA) for field program	Tetra Tech PM Tetra Tech QAM Navy RPM	Linda Klink Tom Johnston Todd Bober	412-921-8650 412-921-8615 215-897-4911	The Tetra Tech QAM will notify the Tetra Tech PM verbally or by e-mail within one business day that the corrective action has been completed. The Tetra Tech PM will then notify the Navy RPM (verbally or by e-mail) within 1 business day
Field data quality issues	Tetra Tech FOL/SSO Tetra Tech PM	Brian Geringer Linda Klink	978-204-8785 412-921-8650	The Tetra Tech FOL will inform the Tetra Tech PM (verbally or via e-mail) on the same day that a field data quality issue is discovered.

Communication Driver	Responsible Affiliation	Name	Phone Number and/or E-Mail	Procedure
Analytical data quality issues	Katahdin Laboratory PM Tetra Tech Project Chemist Tetra Tech DVM Tetra Tech PM Navy RPM	Jennifer Obrin Matt Kraus Joseph Samchuck Linda Klink Todd Bober	207-874-2400 412-921-8729 412-921-7281 412-921-8650 215-897-4911	The Laboratory PM will notify (verbally or via e-mail) the Tetra Tech Project Chemist within 1 business day of when an issue related to laboratory data is discovered. The Tetra Tech Project Chemist will notify (verbally or via e-mail) the data validation staff and the Tetra Tech PM within 1 business day. The Tetra Tech DVM or Project Chemist will notify the Tetra Tech PM verbally or via e-mail within 48 hours of validation completion that a non-routine and significant laboratory quality deficiency has been detected that could affect this project and/or other projects. The Tetra Tech PM will verbally advise the NAVFAC RPM within 24 hours of notification from the Project Chemist or DVM. The NAVFAC RPM will take CA that is appropriate for the identified deficiency. Examples of significant laboratory deficiencies include data reported that have a corresponding failed tune or initial calibration verification. CAs may include a consult with the NAVFAC Navy Chemist.
Site utilities clearance for intrusive activities	Tetra Tech FOL NAS Brunswick POC	Brian Geringer Bob Leclerc	978-204-8785 207-406-2290	The Tetra Tech FOL and Tetra Tech Geophysicist will coordinate verbally or via e-mail with the facility POC at least 7 days in advance of site access and 2 weeks in advance of drilling operations to plan the utility clearance of all well boring locations.

Communication Driver	Responsible Affiliation	Name	Phone Number and/or E-Mail	Procedure
				The Tetra Tech FOL will coordinate utility clearance verbally or via e-mail with the Maine One Call system representative, Dig Smart of Maine, and the drilling subcontractor prior to drilling.
Munitions and Explosives of Concern (MEC)/Material Potentially Presenting an Explosive Hazard (MPPEH) Finds	Tetra Tech UXO Escort Tetra Tech UXO Manager Tetra Tech FOL Tetra Tech PM Navy RPM NAS Brunswick POC USEPA MEDEP	TBD Norm Piper Brian Geringer Linda Klink Todd Bober Bob Leclerc Mike Daly Claudia Sait	TBD 770-413-0965 x228 978-204-8785 412-921-8650 215-897-4911 207-406-2290 617-918-1384 207-287-7713	Immediately upon finding MEC/MPPEH, the Tetra Tech UXO Escort will verbally notify the Tetra Tech FOL, mark the area with pin flags, and avoid the item. Within 30 minutes of the MEC/MPPEH find, the Tetra Tech UXO Escort will verbally notify the UXO Manager, and the Tetra Tech FOL will verbally notify the Tetra Tech PM and NAS Brunswick POC. Tetra Tech PM will notify the Navy RPM verbally or via e-mail on the same day. The Navy RPM will make notifications as stated in the approved Explosives Safety Submission (ESS). The RPM or designee will inform the Project Team via e-mail within 2 business days.

SAP Worksheet #7 -- Personnel Responsibilities and Qualifications Table

(UFP-QAPP Manual Section 2.4.3)

Name	Title/Role	Organizational Affiliation	Responsibilities
Todd Bober	Navy RPM/Manages project activities for the Navy	NAVFAC BRAC PMO NE	Oversees project implementation including scoping, data review, and evaluation.
Paul Burgio	BRAC Environmental Coordinator)/Manages BRAC activities for the Navy	NAVFAC BRAC PMO NE	Coordinates BRAC Environmental activities for the Navy.
Claudia Sait	RPM/Provides regulator input	MEDEP	Participates in scoping, conducts data review and evaluation, and approves the SAP on behalf of MEDEP.
Jeff Orient	Activity Coordinator/ Oversees project activities	Tetra Tech	Oversees project implementation including scoping, data review, and evaluation for all Tetra Tech projects at NAS Brunswick.
Linda Klink	PM/Manages project on a daily basis	Tetra Tech	Oversees project, financial, schedule, and technical day-to-day management of the project.
Norm Piper	UXO Manager/Managers project UXO activities	Tetra Tech	Manager of UXO Escort/Anomaly Avoidance operations
Brian Geringer	FOL/SSO/Manages field operations and oversees site activities to ensure that safety requirements are met	Tetra Tech	As FOL, supervises, coordinates, and performs field sampling activities. As SSO, is responsible for on-site project-specific health and safety training and monitoring site conditions. Details of these responsibilities are presented in the HASP.
TBD	UXO Escort/Provides UXO Escort to anyone on site.	Tetra Tech	Provides escort to all field personnel and visitors throughout the MRP site and utilizes Anomaly Avoidance techniques during all on-site activities.
Tom Johnston	QAM/Oversees program and project QA activities	Tetra Tech	Ensures that quality aspects of the CLEAN Program are implemented.
Matt Soltis	HSM/Oversees health and safety activities	Tetra Tech	Oversees the Tetra Tech CLEAN Program Health and Safety Program.
Matt Kraus	Project Chemist/Conducts project oversight of data validation and reporting	Tetra Tech	Participates in project scoping, prepares laboratory scopes of work, and coordinates laboratory-related functions with laboratory. Oversees data quality reviews and QA of data validation deliverables.
Joseph Samchuck	DVM/Oversees data validation activities	Tetra Tech	Manages data validation activities within Tetra Tech, including ensuring QA of data validation deliverables, providing technical advice on data usability, and coordinating and maintaining the data validation review schedule.

Name	Title/Role	Organizational Affiliation	Responsibilities
Lee Leck	Data Manager/ Oversees database activities	Tetra Tech	Manages Tetra Tech databases and ensures input of data.
James Coffman	Project Geophysicist/Performs project related geophysical activities.	Tetra Tech	Manages geophysical surveys
Jennifer Obrin	Laboratory PM/Manages project	Katahdin	Coordinates analyses with laboratory chemists, ensures that the scope of work is followed, provides QA of data packages, and communicates with Tetra Tech project staff.
TBD	Drilling Subcontractor PM/ Provides Drilling Services	TBD	Performs monitoring well installations and soil boring installation according to the scope of work.
TBD	Surveyor	TBD	Performs surveying of sample locations according to the scope of work.

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

SAP Worksheet #8 -- Special Personnel Training Requirements Table

(UFP-QAPP Manual Section 2.4.4)

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

UXO Anomaly Avoidance personnel must be trained in accordance with Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP)-18. This requires that the UXO Technicians performing Anomaly Avoidance be certified by the Department of Defense (DoD). Tetra Tech will provide qualified UXO Technicians to fulfill the Anomaly Avoidance necessary to support the Munitions Constituents (MC) sampling efforts.

SAP Worksheet #9 -- Project Scoping Session Participants Sheet

(UFP-QAPP Manual Section 2.5.1)

Project Name: Remedial Investigation (RI) **Projected Date(s) of Sampling**: Summer 2012 **Project Manager**: Linda Klink	**Site Name**: Site 12 EOD Area **Site Location**: Brunswick, Maine

Date of Session: December 6, 2011
Scoping Session Purpose: Technical Meeting

Name	Title	Affiliation	Phone Number	E-Mail Address	Project Role
Paul Burgio	BRAC Environmental Coordinator	Navy/ BRAC PMO NE	215-897-4903	paul.burgio@navy.mil	Manages BRAC activities for the Navy
Todd Bober	RPM	Navy	215-897-4911	todd.bober@navy.mil	Manages project activities for the Navy
Bob Leclerc	NAS Brunswick Public Works	Navy	207-406-2290	robert.leclerc@navy.mil	Base POC
Claudia Sait	RPM	MEDEP	207-287-7713	claudia.b.sait@maine.gov	Provides MEDEP regulator input
Chris Evans	Hydrogeologist	MEDEP	207-287-7656	gordon.c.evans@maine.gov	Provides MEDEP regulator input
Mike Daly	RPM	USEPA	617-918-1384	daly.mike@epamail.epa.gov	Provides USEPA regulator input
Linda Klink	PM	Tetra Tech	412-921-8650	linda.klink@tetratech.com	Manages project activities for Tetra Tech
Erica Love	Assistant PM	Tetra Tech	412-920-7009	erica.love@tetratech.com	Assist the Tetra Tech PM
Chuck Race	Geologist	Tetra Tech	978-474-8437	charles.race@tetratech.com	Provides technical input for Tetra Tech
Norm Piper	UXO Manager	Tetra Tech	770-413-0965 x228	norm.piper@tetratech.com	Managers Project UXO-related activities
Catherine Ferdinand	--	Bowdoin College	207-725-3093	cferdina@bowdoin.edu	Representative for Bowdoin College
Denise Clavette	--	Town of Brunswick	207-721-0292 x1	dclavette@ brunswickme.org	Town of Brunswick Representative
Carolyn Lepage	Representative	BACSE	207-777-1049	calepage@roadrunner.com	Technically advises BASCE
Antoinette Mecadaite	--	BACSE	207-443-4550	toniblaeberry@earthlink.net	Representative for BACSE

Project Name: Remedial Investigation (RI) **Projected Date(s) of Sampling**: Summer 2012 **Project Manager**: Linda Klink	**Site Name**: Site 12 EOD Area **Site Location**: Brunswick, Maine

Date of Session: December 6, 2011
Scoping Session Purpose: Technical Meeting

Name	Title	Affiliation	Phone Number	E-Mail Address	Project Role
David Chipman	--	Town of Harpswell	207-607-4130	d.w.chipman@comcast.net	Town of Harpswell Representative
Tom Brubaker	--	MRRA	207-607-4189	tomb@mrra.us	Representative for MRRA

Comments/Decisions (concerning subject Site 12 only):

1. Data Gaps (Catherine Ferdinand): Expressed concern with regard to possible data gaps that may arise between investigations (Time-Critical Removal Action [TCRA] to RI). Todd Bober and Linda Klink responded that the TCRA is a portion of the RI and will ultimately be summarized in a comprehensive report. In addition, a Sampling and Analysis Plan (SAP) will be provided before further investigation that will include all relevant information gathered to date.

2. Paul Burgio asked at what depths were items uncovered at Site 12. Erica Love responded that all items were found between 0 and 4 feet below ground surface (bgs), the maximum depth of the trenches. Typically, bedrock and/or groundwater were encountered above the 4 feet maximum depth. Note that following the meeting, a review of the data from the trenching activities showed that munitions items were identified between 3 and 42 inches bgs, with the majority of items identified deeper than 1 foot bgs.

3. Site 12 MEC/MC SAP Development, (presented by Linda Klink): Linda noted that the presentation was based on the draft MC Investigation Strategy Package previously reviewed by the Navy, USEPA, and MEDEP and a subsequent November 2011 site visit.
   a. Claudia Sait inquired about the need to perform additional investigations outside the perimeter of the currently shown Site 12 boundary. Linda Klink responded that no additional MEC investigations are warranted at this time, with the exception of the pond and the one existing berm inside the Site 12 boundary. The perimeter boundary was established based on findings to date (i.e., perimeter road and absence of ground surface MEC/MPPEH working outward from central historical berm operational area).

b. Linda Klink was questioned about the rationale for selection of analytes. MC analytes for all media will include explosives (including nitroglycerin), metals, and additionally perchlorate in groundwater. Hazardous waste constituents are not anticipated because only construction debris was found at Site 12 to date, but to confirm the absence of hazardous waste constituents on site, select samples will also be analyzed for an expanded analyte list including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and Extractable Petroleum Hydrocarbons (EPH)/ Volatile Petroleum Hydrocarbons (VPH).
c. Incremental Sampling Methodology (ISM) was described as a more involved form of composite sampling that will be used in conjunction with discrete sampling to meet project objectives.
d. Claudia Sait asked how discrete sampling locations were chosen in Decision Unit (DU) 2 – Berm Area. Linda Klink explained that the sample locations were determined using a combination of bias toward surface MEC finds in addition to having coverage over the entire DU. Sample locations will be placed near subsurface anomalies, while understanding that samples cannot be collected directly over an anomaly because of munitions concerns.
e. Discrete sampling at DU1 – Existing Berm Mound was discussed, and Mike Daly questioned the rationale for the 18-inch maximum sampling depth into the sidewall of the berm. Linda Klink responded that the berm was used as a natural engineering control during detonation; therefore, contamination is expected to be present on the surface of the inside facing walls, and sample depth is biased towards the inside walls of the berm.
f. Claudia Sait presented a historical topographic map (date unknown) that showed the location of a historical berm area adjacent to (southeast of) the existing berm. The new berm area will be added to the MC Investigation Strategy Package, and sample numbers will be reordered so that four discrete sample locations will be associated with all historical berms (DU2A through DU2E), for a total of 20 surface and 20 subsurface soil samples. Following the meeting, historical photographs were reviewed, and it appears that the referenced berm area consists of a double berm (appears as two joined berms) and was present through the mid-1990s. Linda Klink noted that the newly identified berm lies within the “red box” of DU2 and so is already captured in the existing DU2 incremental sampling plans. *Note that the sampling scheme for DU2 was revised subsequent to the meeting, during regulatory review of the draft SAP.*
g. David Chipman inquired about the location of MC samples associated with DU5 – Pond. Linda Klink indicated the current size of the pond is smaller than that shown in historical aerial photography and that both sediment and soil samples, as appropriate based on current-day conditions would be collected along the former centerline of the pond covering the historical extent.
h. DU6 – Groundwater was discussed. Very low frequency (VLF) geophysical surveys will be used throughout the site along transects to locate deep fractures. Ground-penetrating radar (GPR) will

be used in a focused survey to confirm the locations of the fractures as shallow. Well locations will generally be located downgradient of the existing and former berm sites. A decision point will be included in the SAP following collection of geophysics data such that regulators will have input on monitoring well placement. In addition, mapping of surface strikes and dips needs to be included in the SAP. *Note that the need for geophysics may no longer be warranted based on investigation conducted subsequent to the meeting.*

Action Items: Tetra Tech was assigned the task of preparing the draft UFP-SAP.

1. Tetra Tech to distribute MEC-Hazard Assessment to attendees for reference (DONE: see below).
   a. http://www.epa.gov/fedfac/documents/hazard_assess_wrkgrp.htm

2. Tetra Tech to provide ISM guidance (DONE: see below)
   a. http://www.itrcweb.org/teampublic_ISM.asp
   b. http://www.itrcweb.org/Documents/TeamResources_MIS/Final8330BImplementationGuide061708.pdf

3. Claudia Sait requested that Tetra Tech look into the documented MEC items previously used on the base and compare information about them to the found items, specifically the rifle grenade found at the Quarry (DONE: see below).
   a. The M28 rifle grenade is not listed as one of the documented munitions items stored or used on base. However, the former Explosives Ordnance Disposal (EOD) unit is known to have accepted various souvenirs for disposal. (See Appendix D of the Preliminary Assessment Addendum (Malcolm Pirnie, 2007) containing the munitions items documented at Site 12 EOD Area and the Technical Data Sheets associated with those items).

4. Tetra Tech is to provide the revised Final MC Investigation Strategy Package for Site 12 to the Project Team and begin working on the Draft UFP-SAP for MC. (DONE. Additions to the draft Strategy Package are noted below – supporting historical maps associated with items a and b below are provided in Appendix F).
   a. Tetra Tech found an additional Survey Map of Site 12 showing the additional berm area adjacent to the existing berm and distributed it as part of the revised Investigation Strategy Package.
   b. Tetra Tech found a Site 12 construction drawing dated July 21, 1981 that provides additional information on the site pond as a repository for trees to be cut during EOD area preparation (Appendix A).

c. The steep-rocky slope was incorrectly located on previous maps of Site 12, during the TCRA investigation, the area boundary was recorded using a global positioning system (GPS), and the correct area will be shown on all SAP maps.

Consensus Decisions: The meeting participants developed the overall strategy for the initial RI sampling. Consensus decisions included the following:

1. <u>Site 12 EOD Area and Quarry Area</u>
   a. Site 12 and Quarry MC SAPs will be separate documents rather than combined.
   b. The Project Team agreed that VLF geophysics will be conducted across Site 12 and Quarry to locate fractures and that focused GPR surveys will be conducted in the areas for monitoring well placement to ensure that the fractures are shallow at the planned locations. A decision point will be included following collection of the geophysics data such that regulators will have input on monitoring well placement. *Note that the need for geophysics may no longer be warranted based on investigation conducted subsequent to the meeting.*
   c. In addition to geophysics, mapping of surface strikes and dips needs to be included in the SAPs as a discrete task.

2. <u>Site 12 EOD Area</u>
   a. As per the MEDEP-provided aerial photograph, the mid-1990s berm area will be added to the figures and to the DU2 sampling program as DU2E, and sample locations will be distributed evenly among the five DUs.
   b. The new berm area (1996) will be added to the MC Investigation Strategy Package, and sample numbers will be reordered so that four discrete sample locations will be associated with all historical berms (DU2A through DU2E), for a total of 20 surface and 20 subsurface soil samples. *Note that the sampling scheme for DU2 was revised subsequent to the meeting, during regulatory review of the draft SAP.*
   c. A decision point will be included in the SAPs following collection of the geophysics data such that regulators will have input on monitoring well placement. *Note that the need for geophysics may no longer be warranted based on investigation conducted subsequent to the meeting.*

SAP Worksheet #10 -- Site History *and Background*

(UFP-QAPP Manual Section 2.5.2)

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
*R*ange/Site Profile	Installation Name	Former NAS Brunswick
	Installation Location	Cumberland County, Maine
	Range/Site Name	Site 12 EOD Area
	Range/Site Location	Located in the southeastern portion of the installation, approximately 4,300 feet southeast of Building 539 (Figure 10-1).
	Range/Site History	It is unclear when munitions-related activities began at Site 12. However, based on a 1978 aerial photograph identified by MEDEP, a berm-like feature appears to have been located on the site, indicating that munitions-related activities were occurring as early as 1978. An as-built construction drawing of the Site 12 EOD Area, dated July 21, 1981 (provided in Appendix F) indicated an access road entering from the west, a central berm, and a shelter for observing detonations. A note on the figure indicates that a swamp located on the eastern side of the site (in the current location of the Pond) was filled with stumps and dirt from the site clearance. A radius of 500 feet around the central berm was cleared of trees during the construction of the site. Beginning in 1981, the site was used for disposal of small quantities of ordnance, pyrotechnics, privately manufactured explosives, and war souvenirs. Use of the range was officially terminated on June 1, 2004. A portion of the site is also suspected of being a former sand/gravel pit. Based on the results of 2010 trenching activities in the current and historical berm area of the site, the site was also used as a landfill for construction- related debris such as concrete pipes, culverts, scrap metal, and rebar. The landfill activities may have been co-located with the sand and gravel quarry activities, but there is no historical documentation of either of these activities.

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
	Range/Site Area and Layout	The site consists of a 112.7-acre Surface Danger Zone (SDZ) based on the Inhabited Building Distance (IBD), but based on the 2010-2011 TCRA, the actual area expected to contain MEC/MPPEH is significantly less. The actual area, approximately 19 acres, is roughly the area included with the perimeter road on the north, west, and south and encompasses the pond to the east (Figure 10-2). Located at the center of the site is a 5- to 6-foot-high semi-circular earthen berm approximately 60 feet long by 100 feet wide. Two small demolition craters and a dumpster were located at the center of the site. The dumpster was removed in the 1990s. Following completion of the geophysical investigation during the SI, the existing and historical berms (detonation area) appeared to extend beyond the expected area based on the locations of subsurface anomalies at the edges of the investigation area. During the TCRA, unexpected non-munitions-related debris (culverts, rebar, concrete, piping etc.) was discovered and indicated that landfilling of construction debris also occurred at the site.
	Range/Site Structures	The Site 12 EOD Area includes a 5- to 6-foot-high earthen berm. One former control bunker is located approximately 200 feet southwest of the existing berm. The berm is an attractive nuisance, which may entice people to walk on, dig, in or in some way disturb the existing berm, and represents a long-term management issue due to exposure to MEC from erosional and other processes.
	Range/Site Boundaries	North: Marine Corps Armed Forces Reserve Center South: Undeveloped land (pine forest), Buttermilk Mountain East: Unnamed stream, Maine State Route 24 West: Access road, undeveloped land (pine forest)
	Range/Site Security	The overall site is currently unrestricted. In February 2012, the Navy determined a Land Use Control fence was needed around the western and northern side of Site 12, which would join existing fencing to the south and east to enclose the site completely. Fence installation will occur in June 2012.

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
Munitions/ Release Profile	Munitions Types	Ordnance, pyrotechnics, privately manufactured explosive devices, and war souvenirs. A complete list along with other site uses can be found in Appendix D of the Preliminary Assessment (Malcolm Pirnie, 2006). Site discoveries during the Site Inspection (SI) (on the ground surface) included two smoke grenades, one unidentified munitions-related item that might possibly be a jet assisted take off (JATO) M8 rocket motor, one 3-inch cartridge case, one 2.2-inch rocket motor (munitions debris), and one gator mine. During the 2010-2011 TCRA, discoveries (on the ground surface) within the perimeter road included the following: • Inert 500-pound MK82 bomb (with fuze). • Multiple unknown fuzes and components. • 40mm cartridge cases with live primer. • 40mm practice grenade. • M-18 smoke grenades (expended with fuzes). • 60mm mortar. • Small quantity of bulk propellant exposed in an unknown rocket type. • 20mm projectiles with and without fuzes. • M904 bomb nose fuze. • 75mm projectile base. • 81mm practice mortar empty, unfuzed, solid. • AN-Mk228 Tail Fuse fully loaded. • Gator Mine (labeled inert, blue). Munitions-related items identified in the subsurface during limited trenching activities included the following: • 75mm projectile base • Munitions Fragments • Ballistic shield • 40mm cartridge base • Ejection cartridge base • Unknown fuzes • 37mm cartridge base • 2.5 inch rocket motor • Rocket motor venture • 2.25-inch Sub-Caliber Aircraft Rocket (SCAR) warhead • 2.75-inch rocket venture • Rotating band (5 inches) • Unknown fuzes • Mk34 torpedo • Small amount of bulk high explosive (HE)

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
	Maximum Probability Penetration Depth	Munitions destroyed with explosives by certified EOD personnel and not fired. Because none of the munitions were fired at the site, the maximum probability penetration depth is approximately 1 foot bgs in the outer reaches of the site for kick-outs from the detonations and 4 feet bgs within the existing and historical berm areas considering that munitions would have been buried prior to treatment via detonation. It is also possible that MEC/MPPEH were disposed of at the pond on the eastern edge of the site, although no historical records indicating disposal in the pond were identified.
	MEC Density	MEC density was expected to be moderate within the existing and historical earthen berm areas due to the reports of numerous small munitions fragments existing on site and based on typical EOD site operations. This was confirmed during the SI during which anomaly density around the berms was determined to be moderate to high although covering a more extensive area than anticipated; the geophysical survey indicated that one of the 100 x 100 foot grids had a maximum of 90 percent coverage with anomalies, in the area surveyed. MEC density is assumed to be low outside of the berm area but inside the perimeter road, due to possible kick-out from operations or training activities. This was confirmed during the SI and TCRA. During the 2010-2011 TCRA, items were primarily found in the central portion of Site 12 near the current berm area in surface and subsurface soil, although several training items and kick-outs were found on the ground surface in the outer area of the site.
	Munitions Debris	Blank 5.56mm and blank 7.62mm rounds were observed on the perimeter road although no munitions scrap/fragments were found during the PA visual survey; however, limited access due to EOD hazard concerns did not allow a visual survey of the entire site. In the past, several small munitions fragments have been observed in surface soil inside the earthen berm area. During the SI and TCRA, numerous items [MEC/MPPEH and Material Documented as Safe (MDAS)] were encountered at the ground surface and in the limited trenching activities described above. Munitions debris found outside the historical berm area may be associated with kick-outs from the berm areas or the result of isolated training events using inert items, which may have occurred anywhere within the perimeter road.

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
	Associated MC	Potential associated MC are metals (lead, antimony, copper, and zinc), explosives (TNT, RDX, HMX, nitroglycerin, black powder, white phosphorus, red phosphorus, tetryl), and perchlorate. MC are expected to be found in a similar pattern as the MEC/MPPEH, with elevated concentrations near the center of the site at the existing berm and historical berms. For the center area of the site, both surface and subsurface soil are of concern because munitions items are typically buried prior to detonation as a form of engineering control to tamp the explosions. In the outer areas of the site, MC are expected to be limited to surface soil, concentrations are expected to be lower, and more sporadic from kick-outs, considering explosives constituents are typically consumed during detonation. No appreciable concentrations of MC are expected from the few training items found on site. In addition to the munitions-related items, construction debris (concrete, rebar, culverts, etc.) was also found in subsurface soil during limited trenching in the central portion of the site performed during the 2010-2011 TCRA. No chemical sampling has been conducted to date nor have any suspect hazardous waste source items been discovered. Two 55-gallon drums have been found onsite and similar drums have been used to contain scrap metal on EOD ranges. Based on the fact that only construction debris has been found to date and no evidence of hazardous waste (labels, staining, etc.) have been identified associated with the drums, hazardous waste is not expected to be present ; but confirmation is needed via analysis of VOCs, SVOCs, and EPH/VPH, that non-munitions related hazardous constituents are not present site-wide.
	Associated Hazardous Waste Constituents	Hazardous waste constituents (VOCs, SVOCs, EPH, and VPH) are not anticipated because only construction debris was found at Site 12 to date. Although two 55-gallon drums were identified on site, there were no indications of any associated hazardous constituents present.
	Migration Routes/ Release Mechanisms	Potential MEC migration routes include migration of MEC from subsurface soil to the surface via erosion or frost heave around the existing/historical berms. Potential MC may be released from former surface items or munitions items remaining in the subsurface and migration routes include leaching of MC from soil (surface and subsurface) into groundwater, runoff of contaminants from surface soil to the pond.
Physical Profile	Climate	The area has a continental climate with three well-defined seasons. Highest temperatures occur in July [79 degrees Fahrenheit (^{o}F) or higher] and coldest temperatures occur in January (21°F or lower).
	Topography	The southern half of Site 12 is relatively flat. The northern half of the site is marked by undulating hills and is approximately 10 feet higher in elevation than the southern half.

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
	Geology	The geology of the site is only partially understood and was first based on three test pits excavated within the current berm area during 1991. In two of the test pits, micaceous schist was encountered at 3 feet bgs underlying fill or disturbed soil over 1 to 2 feet of very dense till. The third test pit had 2 feet of fill or disturbed soil overlying desiccated, very stiff, gray silty clay. Bedrock was encountered at less than 3 feet bgs in two of the three test pits in the berm area but was not encountered in a third pit excavated to 6 feet bgs. Bedrock was encountered at approximately 2 to 4 feet during 2010 TCRA trenching activities. Bedrock at Site 12 EOD Area is mapped as the Cape Elizabeth Formation. Bedrock depressions are oriented north-northeast and northeast and range in size from 50 to 130 feet in width and 5 to 20 feet in depth. Bedrock ridges have steep west-facing slopes, and joints strike west-northwest and dip steeply to the south-southwest or north-northeast.
	Soil	Suffield-Buxton-Hollis Association - deep to shallow, moderately well-drained to somewhat poorly drained soils with low permeability
	Hydrogeology	There are no wells within the boundary of the site and so no cross sections have been developed to date; however, based on the TCRA trenching efforts, the groundwater table is estimated to be approximately 4 feet bgs. The closest private drinking water wells are approximately 2,000 feet east of the site along Coombs Road. A groundwater divide bisects the Site 12 EOD Area; a portion of the groundwater flows west toward Mere Brook and a portion flows east toward the site pond just east of the perimeter road. The pond on the eastern side of the site is located in a rocky area, and its connection to groundwater is unknown. There appears to be no pond outlet stream at the northern end of the pond; however, it could be intermittent and normally dry.
	Hydrology	Currently surface water is contained within the pond and there appears to be no continuous outflow. However, a discolored discharge leading to a culvert was identified in April, 2012 near the southeastern edge of the site along Old Gurnet Road, which may be an intermittent discharge point from the site.
	Vegetation	Vegetation at the site consisted of tall grasses within the perimeter road (cut during the 2010 TCRA activities), wetland areas, and maple and pine trees in the surrounding area.
Land Use and Exposure Profile	Current Land Use	The site is closed and inactive but accessible at this time. Access control (site fence installation) is planned for June 2012.
	Current Human Receptors	Potential receptors include Navy and civilian personnel inspecting the site, contractors performing investigations on site, and visitors and trespassers. There is no complete pathway for groundwater at this time because groundwater is not used at this site.
	Current Activities	The site is closed and not in use but accessible by visitors/trespassers at this time. Access control (site fence installation) is planned for June 2012.

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
	Potential Future Land Use	Potential future land use is anticipated as the Brunswick Naval Air Station (BNAS) Conservation District (Natural Area). Civilian use of the property is also a potential.
	Potential Future Human Receptors	Potential future human receptors may include personnel/visitors to the Marine Corps Armed Forces Reserve Center (located just north of Site 12) as well as the recreational users. Additionally human receptors could include future construction, maintenance, site occupational workers, and hypothetical future residents. Human receptors may come into direct contact with MEC in the subsurface (surface was cleared during TCRA) and/or MC in surface or subsurface soil (contractors). There is no planned future use of groundwater. Note that although the ground surface has been cleared of MEC/MPPEH, currently or over time subsurface munitions-related items through erosional processes or frost heave, MEC/MPPEH migrate to the surface.
	Potential Future Land Use Related Activities	Potential future land use-related activities in the Conservation District (Natural Area) will include light recreational activities by civilians (walking, hiking, and bird watching).
	Zoning/Land Use Restrictions	Land use restrictions for excavation and groundwater use have been voluntarily enacted by the base and were in place until base closure on May 30, 2011 In February 2012, the Navy determined a Land Use Control fence was needed around the western and northern side of Site 12, which would join existing fencing to the south and east to completely enclose the site. The planning is currently in progress.
	Demographics /Zoning	Cumberland County population density is 50,000 persons per square mile.
	Beneficial Resources	There are no beneficial resources on the Site 12 EOD Area.
Ecological Profile	Habitat Type	The site is a tall grass. Maple and pine forest surround the area. There are wetlands located across the central portion of the site. There is a pond located on the eastern side of the site.
	Degree of Disturbance	Low - the site is currently unused. The habitat and species present are, and will likely be, undisturbed.
	Ecological Receptors and Species of Special Concern	Potential ecological receptors include mice, shrews, voles, rabbits, fox, squirrels, deer, hawks, and occasionally moose. NAS Brunswick also attracts a wide variety of avian species including owls, woodpeckers, and numerous passerine and falconiform species. No species of special concern are known to inhabit the site.

Profile Type	*Information Needs*	*Preliminary Assessment/TCRA Findings*
	Relationship of MEC/MC Sources to Habitat and Potential Receptors	The ground surface of the Site 12 EOD Area was cleared of munitions-related items during the TCRA. Receptors may come into direct contact with MEC/MC in subsurface soil, while burrowing. Receptors may come into contact with MC that have been incorporated into the food chain (bioaccumulated in plants and animals) (e.g., deer that inhabit the area may come into contact with MC while foraging by consuming plants that have incorporated MC). Ecological receptors could also come into contact with potential MC in the subsurface while digging for food or constructing burrows.

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

(UFP-QAPP Manual Section 2.6.1)

Project quality objectives (PQOs) for the Site 12 MC RI are presented in this section. The PQOs document the environmental decisions that need to be made at a site as well as the level of data quality necessary to support these decisions. To establish PQOs for the site, the USEPA's seven-step Data Quality Objective (DQO) process was followed (USEPA, 2005).

11.1 PROBLEM STATEMENT

Based on the history of site operations chemical contaminants may have been released to surface or subsurface soils in the form of MC or hazardous waste. These chemicals could pose an unacceptable level of human health risk or risk to ecological receptors. In addition, if chemical release occurred, the chemicals may have migrated to other environmental media such as groundwater, which also could pose an unacceptable level of risk to human or ecological receptors. Therefore, the project team must determine the nature and extent of contamination, if present, and must assess the level of human health and ecological risks so appropriate action can be taken, as necessary, to be protective of human health and the environment.

11.2 INFORMATION INPUTS

The following data are needed to resolve the problem statement presented In Section 11.1:

Physical Data - Soil/Bedrock/Sediment: Lithology data are needed to characterize soil, sediment, and uppermost bedrock at the site (to the termination depth of monitoring wells), to refine the CSM, and to understand the fate and transport of contaminants in the environment. The fate and transport information are useful for evaluating future risks.

Groundwater Water Quality Data: Measurement of groundwater water quality parameters, consisting of pH, specific conductance, turbidity, temperature, oxidation-reduction potential (ORP), and dissolved oxygen (DO), must be conducted to ensure that groundwater samples are sufficiently representative of geologic formation water and to assist with characterization of the surficial aquifer.

Groundwater Level Measurements: Water level measurements (via water level meter) are needed to provide information regarding the potentiometric surface (i.e., elevation) of the water table at sampling

locations and to determine the direction(s) of groundwater flow. Monitoring wells allow for the collection of sufficiently accurate groundwater level measurements to meet this objective.

Contaminant Concentrations in Soil, Sediment, and Groundwater: Unbiased and representative estimates of mean contaminant concentrations are needed for soil in the existing berm, the Overall Berm Area, and Outer Berm areas as inputs into the HHRA and ERA. ISM may be used to sample soil to provide these estimates.

Estimates of contaminant concentrations in soil at discrete locations near the pond are also needed to provide information on potentially elevated concentrations for surficial and subsurface soil in two areas where historical aerial photographs indicate soil may have been bladed in the pond. Estimates of contaminant concentrations in sediment at discrete locations are needed to provide information for surficial and shallow subsurface sediment to determine nature and extent. Estimates of contaminant concentrations in groundwater within the Overall Berm Area are needed to needed to evaluate the potential for subsurface contamination as a result of burial of munitions prior to detonation and/or contaminant migration via leaching to groundwater, as well as estimate the level of risk to the hypothetical future human receptor that uses the groundwater as a potable water source.

Pond Characterization: General characterization of the pond is needed because the pond may need to be drained as part of a future MEC RI. Therefore, surface water quality data is needed to aid in the MEC RI planning effort the data will be collected during the MC investigation for efficiency purposes and will not be used for MC remedial decision making purposes regarding the pond. In addition, information such as pond depth to calculate the estimated volume of water in the pond and the location of inflows/outflows will also be collected during the MC RI.

Sample Location Data: For soil and sediment sample locations, measurement of horizontal coordinates using a GPS unit with sub-meter accuracy (or better) provides sufficient accuracy and precision. For groundwater monitoring wells and a staff gauge located around the pond, horizontal location and vertical elevation coordinates must be surveyed by a licensed land surveyor. Depth intervals are best measured using a tape measure or other device with similar accuracy and precision (e.g., water level meter). Coordinates must be collected at each sampling location, and the analytical data must be plotted spatially at each sample location.

These coordinates must be documented in the Maine State Plane, U.S. survey feet, North American Datum (NAD) of 1983 (NAD 83) and North Atlantic Vertical Datum (NAVD) 88. For ISM grids, the vertices

of the grid over which incremental samples are collected must be documented using a GPS with sub-meter accuracy (or better). .

Geologic and Geophysical Survey Data: A map including strike and dip measurements of bedrock fractures (e.g., foliation, joints), and information on fracture spacing and coatings must be prepared to identify geologic features of Site 12 that effect groundwater flow. All features must be plotted on a recent aerial photograph. Bedrock fracture strikes and dips must be collected with a Brunton compass and documented using a rose diagram to identify the predominant fracture directions at the site. In addition, an equal area stereonet must be prepared to determine the dip direction and magnitude associated with the predominant fracture directions.

Laboratory-Analyzed Chemical Data: Surface and subsurface soil (select samples), sediment, and groundwater samples must be analyzed for explosives (including nitroglycerin), TAL metals, VOCs, SVOCs, perchlorate (groundwater only), EPH, and VPH. Worksheet #15 lists all chemicals to be analyzed, required sampling methods are presented in Worksheet #17, and required analytical methods are presented in Worksheet #19. These data are needed to assess risks to human and ecological receptors and to define the extent of contamination in soil, groundwater, and sediment at Site 12.

Project Screening Levels: The analytical data must be compared to Project Screening Levels (PSLs) for the selection of soil, sediment, and groundwater chemicals of potential concern (COPCs) in the HHRA and ERA. PSLs are identified in Worksheet #15; the minimum value of all applicable criteria that were considered is presented. Backup tables supporting the selection of the human health and ecological screening values are provided in Appendices D and E, respectively.

The project schedule is being expedited so that a Record of Decision (ROD) can be in place by 2013. Therefore, unvalidated analytical results will be screened against PSLs and provided to the Navy and regulators when available so that an early decision can be made by the Project Team regarding the need for additional monitoring wells and to initiate early discussion on development of remedial alternatives for the Feasibility Study (FS) can be initiated before the RI is completed.

To support the risk assessment and comparisons of site data to PSLs, the selected laboratories must be able to achieve Limits of Quantitation (LOQs) that are low enough to measure constituent concentrations less than the PSLs with confidence. In cases where conventional test methods are not able to achieve LOQs that are less than the PSLs (such as for arsenic and selected explosives), rules for evaluating the data are required that help the Project Team determine with reasonable satisfaction whether the

constituent poses a potentially unacceptable risk. Analytical data reported by the laboratory must use the following reporting conventions:

- All concentrations less than Limits of Detection (LODs) will be classifies as non-detects and will be reported as DL values with a "U" qualifier.
- Concentrations between the LOQ and LOD will be reported as estimated values with a “J” qualifier.

The “J” flagged data will be accepted to achieve project goals. The inability to quantifiably compare individual analytes to PSLs with confidence must be addressed in the risk evaluation uncertainty analysis in each risk assessment.

Background Data: Background concentrations of metals and polynuclear aromatic hydrocarbons (PAHs) are needed to differentiate between site-related chemicals and those chemicals occurring naturally or through anthropogenic inputs. Therefore, Site data will be compared to background values lines of evidence, such as site-specific facility background concentrations such as the concentrations identified in the Background Study Report for Naval Air Station Brunswick, (Tetra Tech, 2012) and/or Maine’s Remedial Action Guidelines (RAGs) Appendix 1 and 2 tables. For areas of the site being compared to background data where three or more ISM sample results are available, a 95% UCL will be calculated on the site ISM data using the 95% UCL calculator for ISM data provided in Section 4 of the 2012 IRTC Incremental Sampling Methodology guidance for comparison to background data. In addition to the 95% UCL, the mean will also be evaluated.

Risk Assessments: In addition to the site-specific risk assessment, a cumulative risk assessment that includes risks from chemicals screened out at the COPC selection phase of the site-specific risk assessment due to background will be completed for informational purpose. Risk assessments are needed to provide an evaluation of hazardous substances which may pose potentially unacceptable risks to receptors exposed to the site media under current or hypothetical future land use. The methodologies for HHRA and ERA are provided in Appendices D and E, respectively. These risk assessments will be conducted in accordance with USEPA protocols and Navy guidance documents for HHRAs and ERAs.

Required QA/QC data are described in Worksheets #12, #20, and #28.

11.3 BOUNDARIES OF THE STUDY

In February 2012, the Navy determined a Land Use Control fence was needed around the western and northern side of Site 12, which would join existing fencing to the south and east to enclose the site

completely. The fence will be installed in June 2012. This fence is expected to limit access to the Site and prevent exposure of humans to subsurface soils. Site 12 has been divided into six potential DUs (DU1 through DU6) based on the CSM, which were selected to account for anticipated differing types (MC or hazardous waste) and contaminant concentrations. The Overall Berm Area is expected to have a higher probability of finding contamination than the outer kickout area. As a result, different remedies for unacceptable levels of contamination are anticipated. Media of interest that must be represented by the data for human and ecological risk assessment were chosen to be reflective of the likely potential for elevated contaminant concentrations within site media, includes surface soil, subsurface soil, sediment, and groundwater. The most shallow surface soil or sediment is expected to be more contaminated than deeper soils based on the CSM. The Project Team determined that biasing soil and sediment data collection toward shallow surface soil (e.g. top 3 inches of soil, for ISM samples) would provide the most conservative risk estimates and thus be the most protective of human health and the environment. In addition, a subsurface ISM sample collected from 3 to 18 inches will also be collected to provide conservative risk estimates for the shallow subsurface of the existing berm, DU1. A summary of each DU and media of interest found within that DU is provided below, and DUs are depicted Figure 11-1.

Surficial groundwater (presumed to be the upper-most top 10 feet of groundwater found within 10 feet of the ground surface) is a media of interest for the entire site and the area representing the greatest potential to be contaminated because of site operations is the region of greatest interest for contamination associated with Site 12. Actual conditions will be established in the field. Based on the CSM, the Overall Berm Area has the potential for the highest contaminant concentrations. To aid in the delineation of contamination DUs were arranged in essentially concentric rings representing areas over which contamination level are anticipated to be relatively uniform but are different from other areas.

11.3.1 Decision Units

DU1 – Existing Berm Mound (Surface and Subsurface Soil)

The media of interest for DU1, located in the center of Site 12, are surface soil (0 to 3 inches bgs) and shallow subsurface soil (3 to 18 inches bgs) located on the inside face of the berm. Because of historical EOD activities, concentrations of MC are potentially elevated, and MEC is likely to be present in these media. MC concentrations must to be measured to support remedial alternatives in the FS. Removal of MEC/MPPEH from the berm may “spread” contamination, if present, however, additional engineering controls (such as personal protective equipment, plastic sheeting, drumming of soils, etc.) will be used to minimize and reduce the spread of berm-related soils if MC are shown to be associated with the berm

through analytical sample data. The horizontal boundary of the investigation is the interior face of the circular berm mound, approximately 200 linear feet long by 6 to 8 feet high (Figure 17-1).

DU2– Overall Berm Area (Surface Soil)

Six subarea DUs (DU2A – DU2F) were identified within DU2 to facilitate risk management decisions related to the current and historic berms at Site 12, which includes the current and all historical berm areas identified from aerial photography to date. These will be used to delineate the nature and extent of contaminant concentrations in DU2 (outlined in red on Figure 11-1). Subareas DU2A, DU2B, DU2C, DU2D, and DU2E, represent the current/historical berms (outlined in black on Figure 11-1) and DU2F represents the non-berm areas or areas between and around the other subunits (all remaining areas within the red outline of DU2. The media of interest for DU2 is surface soil (0 to 3 inches bgs) within the Overall Berm Area (DU2). DU2 is approximately 2 acres west of the Perimeter Road with DU2A through DU2E consisting of 0.4 acres combined and DU2F consisting of 1.4 acres. Historical EOD activities in this area included building and raising multiple berm structures in the central portion of the site. Potentially elevated concentrations of MC are anticipated, and MEC is likely to be present in subsurface soil based on previously identified MEC/MPPEH. Subsurface soil (1 to 4 feet bgs) is a media of interest because detonations typically included burning of items prior to detonation to tamp the kick-outs and will be evaluated through the installation subsurface soil samples collected from the existing berm (DU2A) and the adjacent historical former berms (DU2B, DU2C, and DU2E) and sampling of groundwater discussed below under DU6.

DU3 – Intermediate Area Outside Berm Area (Surface Soil)

The media of interest for DU3 is surface (0 to 3 inches bgs) soil in a band of approximately 200 feet surrounding the central berm area where kick-outs and training activities are expected to have occurred but no evidence of historical berms has been identified. DU3 is expected to have similar relatively uniform MC concentrations based on the distance from the Central Berm Area and expected circular pattern of kickouts. Also this DU had a lower density of MEC/MPPEH (surface was cleared of MEC/MPPEH during the 2010-2011 TCRA). The DU has been divided into two consecutive (semi-circular) sampling units (DU3-a – Inner and DU3-b – Outer) due to the large size of the DU. The horizontal boundaries of the investigation are a 27 full and 4 partial 100- by 100-foot grids (approximately 7 acres) bounded by the DU2 boundary (red) and the DU3 boundary (dark blue) on Figure 11-1.

DU4 – Outer Area Outside Berm Area (Surface Soil)

The media of interest for outer area DU4 is surface (0 to 3 inches bgs) soil in a band of approximately 200 feet surrounding DU3. DU4 is expected to contain the lowest concentrations of surface contamination (MC) and the lowest density of MEC/MPPEH (surface was cleared of MEC/MPPEH during the 2010-2011 TCRA) of all the soil-related DUs. MC concentrations throughout DU4 are expected to be relatively uniform. The horizontal boundaries of the investigation include approximately 20 full and 17 partial 100- by 100-foot grids (approximately 7 acres) bound by the green line on Figure 11-1.

DU5 – Pond (Surface and Subsurface Soil/Sediment)

The media of interest for DU 5 is the entire pond, encompassing sediment within the current and historical extent of the pond and surface soil in disturbed areas that are no longer under water that may have been contaminated from historical activities (grids K8, K9, L8, and L9). There is limited information regarding the history of the pond, and contaminant concentrations in sediment are expected to be reflective of runoff from the site as a whole. To assess potential contamination investigation of the centerline of the narrow historic pond (1978 aerial photograph), which corresponds with the approximate centerline of the current pond, is required. In addition, an apparent intermittent discharge from the site was identified at a culvert located south of the pond and sediment near this culvert is required to assess potential contamination in sediments. The vertical boundary for sediment is 0 to 6 inches below the sediment surface because this is the sediment interval associated with ecological exposure. An additional depth of interest includes 6 to 24 inches below the sediment surface, which may indicate whether munitions-related items are buried in the pond sediment from past disposal activities. Considering a bedrock ledge may be present, the vertical boundary based on actual site conditions may be smaller. The vertical boundary for surface soil samples is 0 to 1 foot bgs, and the vertical boundary for shallow subsurface soil is 1 to 5 feet bgs.

Surface water in locations adjacent to the sediment media of interest will not be investigated as part of the MC investigation because sediment is expected to be the most likely medium in which to detect contamination because contaminants if any are expected to adsorb to fine grained sediments. However, surface water data will be collected during the MC RI for efficiency purposes to aid the preparation of a future MEC RI SAP for the pond which may need to be drained the pond. The limited data collected to support surface water characterization for the future the MEC RI SAP will not be used for decision making purposes.

DU6 – Groundwater

The media of interest for DU6 is surficial groundwater associated with Site 12. In general, groundwater contaminant concentrations must be measured in the surficial aquifer at locations of greatest potential for contamination, such as groundwater underlying the central berm area (DU2). The groundwater media of interest at these sites is presumed to be the uppermost top 10 feet of groundwater found within approximately 10 feet of the ground surface or the first occurrence of groundwater that may have been impacted by leaching of MC or hazardous waste from historical activities; actual conditions will be established in the field.

11.3.2 Risk Assessment Exposure Units

The risk assessment goal for this project is to provide potential cumulative site risks across all media for which a given receptor may be exposed. Potential risks to receptors will be calculated for exposure units (EUs). An EU is the area over which receptor activity is expected to occur. The two most important considerations in defining an EU are the anticipated receptor activity and the spatial distribution of contaminant concentrations. An “exposure unit” (EU) is the area over which receptor activity is expected to occur. The two most important considerations in defining an EU are the anticipated receptor activity and the spatial distribution of contaminant concentrations. Exposure units will be determined following data collection by comparing chemical concentration distributions in DUs to each other to determine whether DUs with similar chemical distributions can be combined. If chemical data from any given DU cannot be combined with another DU to form an EU than that DU will be evaluated as an individual EU. In order to combine datasets from two or more DUs into a single EU those datasets must have similar sets of COPCs with similar concentration ranges (as defined in Appendix D).

For more details on risk assessment methodology, refer to Appendix D and E for HHRA and ERA, respectively.

11.3.3 Temporal Boundaries

Because active UXO operations ceased at Site 12 in 2004, COPC concentrations are not expected to change significantly in any medium during the course of this investigation.

To select effective well installation points, it will be necessary to review the VLF and GPR data. These data, which are only required as a basis for selecting will locations, will be used as the basis for ensuring that groundwater monitoring points are installed where groundwater contamination is likely to be present if one or more releases have occurred.

11.4 ANALYTIC APPROACH

The following decision rules were developed for the Site 12 EOD Area RI:

Note: If a contaminant concentration exceeds the associated PSL listed in Worksheet #15 but is less than an associated background value, that chemical will not be selected as a COPC.

1. If the Project Team determines that data gaps exist following the evaluation of the RI data, convene the Project Team to discuss how to address the data gaps, otherwise proceed to the FS.

   At a minimum, this evaluation will consider the following factors relative to the existing CSM for each environmental medium:
   - Frequency of detection for each constituent
   - Frequency and magnitude of PSL exceedance for each constituent
   - Background concentrations of metals and PAHs that exceed PSLs
   - Magnitude of concentrations within each DU
   - Spatial trends of each contaminant.
   - Evaluation of the relative percent difference (RPD) for discrete samples from the same DU
   - Evaluation of the relative standard differences (RSD) between the ISM sample and replicates from the same DU.

2. It is uncertain if the scraped area shown in the northeast portion of the site on historical aerial photographs should be associated with DU4 or DU5. Physically, the area is soil near the perimeter road and so would be associated with DU4; however, from a perspective of historical operations and any associated chemical contamination, the area is suspected to be more closely associated with DU5. If analytes from any or all of soil samples currently assigned to DU5 (Pond) are more similar to analytical results for DU4, then this area will be reassigned to DU4 (Outer Area) for future risk management decisions. If analytes and/or analyte concentrations are dissimilar to either DU4 or DU5 (e.g., hot spot), a new DU will be assigned.

3. <u>HHRA</u> - If human health risks associated with potential exposures to any medium in any EU exceed an Incremental Lifetime Cancer Risk (ILCR) of 1E-5 or a Hazard Index (HI) of 1 for a target organ or critical effect for the future hypothetical lifelong resident exposure scenario (as evaluated in

accordance with the methodology in Appendix D) in a given EU, or if the USEPA target blood-lead concentration[1] criterion is exceeded AND the background concentration is exceeded (metals and PAHs only), then convene the Project Team to evaluate the need for potential options for risk reduction during an FS for that DU for both chemical and MEC/MPPEH risks, otherwise, recommend no further action for chemical constituents based on HHRA but still proceed to an FS for MEC/MPPEH.

4. ERA - If the ERA based on methodology presented in Appendix E indicates that risks to plants, soil invertebrates, or wildlife are unacceptable in any exposure unit AND background concentrations are exceeded in the same EU, then convene with the Project Team to evaluate potential options for risk reduction during an FS for that EU for both chemical and MEC/MPPEH risks, otherwise recommend no further action for protection of the environment from chemical constituents but still proceed to an FS for MEC/MPPEH.

11.5 PERFORMANCE CRITERIA

The data will be concluded to be of sufficient type, number, and quality if they satisfy the data validation criteria and the usability assessment requirements. In general, this requires that the data be representative of the targeted media population, that the data be generated by sufficiently sensitive analytical methods that are operating within quality control (QC) limits, and that the data are considered comparable in terms of quality and representativeness in light of project objectives and decision rules. Laboratory QC limits and PSLs are presented in subsequent worksheets.

The Partnering Team will use unvalidated data to make an early decision regarding the need for additional groundwater monitoring wells and to begin development of remedial alternatives to be evaluated during the FS. However, the validated results of this investigation will be used to determine whether the quality of data collected is sufficient to support the attainment of project objectives and to make final decisions regarding the need for further investigation. Neither the RI nor FS Report will be

[1] Lead will be evaluated using the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children, Windows Version 1.1, Build 11. Exposure of adults (workers and recreational users) to lead will be evaluated by the adult exposure model (USEPA Technical Review Workgroup for Metals and Asbestos [TRW]). The results of the IEUBK modeling are given in terms of the probability that exposed children will exceed a 10 microgram per deciliter (µg/dL) blood-lead level. The output of the USEPA TRW is the probability that elevated fetal blood-lead concentrations (i.e., concentrations greater than 10 µg/dL) will result due to exposures of women of childbearing age. Those probabilities are compared to the USEPA goal of limiting the probability of exceeding a 10 µg/dL blood-lead concentration to 5 percent.

finalized until validated data is incorporated and evaluated. Performance criteria for laboratory-generated data are normal laboratory QA limits and pre-established detection limits for target analytes, as listed in Worksheet #15. The data quality will be reviewed in accordance with processes described on Worksheets #34 through #37 to ensure that performance criteria have been met and that the data are sufficient for decision-making purposes. The RI MC Report will document the detection limits achieved by the laboratory for all sample analyses, and any associated uncertainties will be discussed in the risk assessment section.

11.6 DEVELOP THE PLAN FOR OBTAINING DATA

The analytical sampling plan and rationale for the MC investigations of the DUs are presented in Worksheet #17. Based on the DQOs presented above, ISM to a depth of 3 inches bgs within DU2, DU3, DU4, and discrete samples to a depth of 5 feet bgs in soil in DU2 and 6 inches bgs for sediment in DU5 was selected for representing EU exposure point concentrations (EPCs). Collection of discrete samples in DU2 was selected to supplement the ISM by delineating potential contaminants vertically.

SAP Worksheet #12 -- Measurement Performance Criteria Table – Field Quality Control Samples

(UFP-QAPP Manual Section 2.6.2)

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPCs)	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Trip Blank	VOCs only	One per cooler containing VOC samples	Bias/ Contamination	No analytes ≥ ½ LOQ, except common laboratory contaminants, which must be < LOQ.	S & A
Equipment Rinsate Blank	All analytical groups	One per 20 field samples per matrix per sampling equipment[1]	Bias/ Contamination	No analytes ≥ ½ LOQ, except common laboratory contaminants, which must be < LOQ.	S & A
Field Duplicate (discrete)	All analytical groups	One per 10 discrete field samples collected per matrix	Precision	Values > 5X LOQ: RPD must be ≤30 [2, 3] (aqueous), ≤50[2, 3] (solid).	S & A
Replicate Samples (ISM)	Explosives and metals (by Incremental Sampling)	DU1 (0-3" interval): Two replicates (triplicate) from DU1 - Existing Berm Surface (see Figure 14-1). DU1 (3-18" interval): One replicate (duplicate) from DU1- Existing Berm Subsurface (see Figure 14-1). DU2: One replicate from DU2A-a and DU2A-b (see figure 14-2). DU2: Three replicates from DU2B through DU2F (see Figures 14-3, 14-4, and 14-5) DU3-a, DU3-b, and DU4: Two replicates (triplicate) each from DU3 – Intermediate Area Outside Berm Area (a- inner and b-outer) and DU4 Outer Area Outside Berm Area (see Figure 14-6) [4]	Precision	Values > 5X LOQ: RSD must be ≤ 50% (solids).	S & A
Cooler Temperature Indicator	All analytical groups	One per cooler	Representativeness	Temperature must be between 0 and 6 degrees Celsius (°C), but samples must not be frozen.	S

1 Equipment rinsate blanks will be collected for non-dedicated pumps and sampling equipment. For disposable equipment, one sample per batch of disposable equipment will be collected.
2 If duplicate values for non-metals are < 5x LOQ, the absolute difference should be less than or equal to 2x LOQ.
3 If duplicate values for metals are < 5x LOQ, the absolute difference should be less than or equal to 4x LOQ.
4 Note: ISM replicates replicate the entire sample collection process and are not split samples of one sample (as is generally done during discrete sampling. Unique replicates (samples) must be collected from DU1, DU2, DU3, and DU4 as indicated on Figures 14-1 through 14-6, Worksheet #17 and Worksheet #18.

SAP Worksheet #13 -- Secondary Data Criteria and Limitations Table

(UFP-QAPP Manual Section 2.7)

Secondary Data	**Data Source** (originating organization, report title, and date)	**Data Generator(s)** (originating organization, data types, data generation/ collection dates)	**How Data Will Be Used**	**Limitations on Data Use**
Bedrock Survey	The Field Investigation of Bedrock in the Explosive Ordnance Disposal Range (January, 2003)	Gannet Fleming; bedrock structure, composition, morphology, and fracturing, December 2, 2002	To help guide survey/sample placement	No limitations are identified for data use.
MEC investigation	Site Inspection Report (2009)	Tetra Tech; visual and geophysical observations of MEC/MPPEH, 2008/2009	To help guide survey/sample placement	No limitations are identified for data use.
MEC investigation	TCRA Report (April 2012)	Tetra Tech; surface and subsurface MEC investigation and surface clearance, 2010-2011.	To help guide survey/sample placement	No limitations are identified for data use.

SAP Worksheet #14 -- Summary of Project Tasks

(UFP-QAPP Manual Section 2.8.1)

14.1 FIELD INVESTIGATION TASK PLAN

Site-specific SOPs have been developed for field activities at NAS Brunswick and are included in Appendix A. Field tasks are summarized as follows, followed by a short description of each task:

- Mobilization/demobilization
- Utility clearance
- Site-specific health and safety training
- Monitoring equipment calibration
- UXO Anomaly Avoidance
- Sample collection (general reference)
- Surface and subsurface soil discrete sampling
- Surface and subsurface soil incremental sampling
- Replicate sample collection
- Sediment sampling (pond) and pond characterization
- Geologic and geophysical surveying (VLF/EM and GPR)
- Monitoring well drilling and installation
- Well surveying
- Well development
- Water-level measurements
- Low-flow purging and groundwater sampling of monitoring wells
- GPS locating
- Investigation-derived waste (IDW) management
- Field decontamination procedures
- Field documentation procedures
- Sample handling
- QC

Mobilization/Demobilization

Mobilization will consist of the delivery of all equipment, materials, and supplies to the site, complete assembly in satisfactory working order of all such equipment at the site, and satisfactory storage at the site of all such materials and supplies. The Tetra Tech FOL or designee will coordinate with the NASB

POC to identify appropriate locations for the storage of equipment and supplies. Stakeholders (USEPA and MEDEP) will be notified by the Tetra Tech PM, 2 weeks prior to mobilization of the name of the driller and surveyor.

Demobilization will consist of the prompt and timely removal of all equipment, materials, and supplies from the site following completion of the work. Demobilization includes the cleanup and removal of waste generated during the performance of the investigation.

Utility Clearance

One week prior to the commencement of any subsurface intrusive activities, the Tetra Tech FOL or designee will contact Dig Safe® of Maine (One-Call), a utility locating company to complete a utility clearance ticket for the areas under investigation. The area will be marked prior to the contact. The Tetra Tech FOL will be responsible for coordinating these activities.

Site-Specific Health and Safety Training

Project-specific safety requirements are addressed in detail in the site-specific HASP/APP. Tetra Tech will submit a site-specific HASP/APP to the Navy that addresses safety requirements in further detail. All field personnel will review and be familiar with the HASP/APP, and a copy will be maintained on site. A site-specific health and safety meeting will be conducted on site prior to initiating field activities. All subcontractor personnel (including substitutes) are required to attend the site-specific health and safety meeting. Site-specific health and safety training will be provided to all Tetra Tech field staff and subcontractors prior to beginning field activities and is addressed in Worksheet # 8. A photoionization detector (PID) will be used as the field instrument for health and safety monitoring.

Monitoring Equipment Calibration

Field equipment will be calibrated in accordance with Tetra Tech SOP-01 - SA-1.1 (water quality meter) and with manufacturers' guidance (PID) by the Tetra Tech FOL or designee. Documentation of field equipment calibration is required. Field equipment will be calibrated at the beginning and end of each day, unless otherwise stated by the equipment manufacturer. Monitoring equipment calibration procedures are described in Worksheet #22.

UXO Anomaly Avoidance

A DoD-certified UXO Technician (referred to in special personnel training on Worksheet #8) will perform UXO Anomaly Avoidance to support sample collection tasks. UXO Anomaly Avoidance will require that a UXO Technician escort all field personnel at the site to provide avoidance of any potential surface and subsurface MEC/MPPEH. All of the proposed sampling locations will first be pre-screened for potential anomalies by a UXO Technician operating hand-held industry-standard metal detectors, and any suspect detection that could possibly represent MEC/MPPEH will be avoided by moving sample locations safely away from these items. For soil borings and installation of monitoring wells a downhole metal detector such as a MG230 or equivalent, will be used to screen the borings in 2 foot intervals prior to advancing the drilling equipment, to a maximum depth of 10 feet for safety purposes based on the maximum depth at which bedrock and munitions-related items are expected to be found at Site 12.

A magnetic locator such as the Schonstedt, GA-52Cx instrument, or equivalent will be used for Anomaly Avoidance operations. The detection depth of the instrument is limited by size and orientation of a target and soil characteristics of the work area. The locators provide an audio signal for response, but do not store data. The magnetic locator does not need to be calibrated. To ensure each detector is operating properly, the operator turns on the instrument and slowly moves the locator towards metal. As the probe advances toward the target, the audio signal will increase. Failure to detect the object is reason to reject the instrument. The detector will be checked daily before starting Anomaly Avoidance activities and after any battery change. The normal setting for the Schonstedt instrument is 2; setting the instrument to 3 or 4 will make it more sensitive and setting the instrument to 1 will make it less sensitive. The instrument will not detect copper, brass, or aluminum munitions.

Sample Collection (General Reference)

All sample collection tasks will be preceded by UXO Anomaly Avoidance as described above. The sampling and analysis program is outlined in Worksheet #18 and shown on Figures 14-1 through 14-6 and 17-1 through 17-5 in Worksheet #17. Sample collection will be in accordance with the SOPs listed in Worksheet #21 and provided in Appendix A. The sampling requirements for each type of analysis (i.e., bottleware, preservation, holding times) are listed in Worksheet #19. Field and laboratory QC samples will also be collected as outlined in Worksheet #20.

Surface and Subsurface Soil Discrete Sampling

Discrete sample collection was established for select sampling units within (DUs 2 and 5). In DU2 (subareas 2A, 2B, 2C, and 2E) discrete subsurface (1 to 5 feet bgs) soil samples will be collected in

accordance with SOP-02 (Soil Sampling, Appendix A). Four discrete samples will be collected within the current or historical berm footprint and evenly spaced for DU2A-a, DU2B, DU2C, and DU2E. In DU 5 (the pond and fill area), surface (0 to 1 foot bgs) and subsurface (1 to 5 feet bgs) soil samples (located in outside of the current pond boundary) will be collected in accordance with SOP-02 (Soil Sampling, Appendix A). Surface and subsurface soil samples will be collected with a hand auger to a maximum depth of 5 feet bgs or collected via split-spoon sampler during monitoring well installation. The subsurface sample discrete interval will be determined in the field from a non-saturated depth between 1 to 5 feet bgs or until bedrock is encountered, based on visual and olfactory observations (PID). If no visual or olfactory observations indicate potential contamination, then samples will be collected from 1 to 3 feet bgs (unsaturated soil).

Discrete soil samples for analytical analysis will be collected using disposable trowels, in accordance with Tetra Tech SOP 2 (Soil Sampling, Appendix A). Each soil sample will be described by the Tetra Tech field representative in accordance with Tetra Tech SOP 03 (Borehole and Sample Logging, Appendix A). Each soil boring log will note the soil type, color, rocks or minerals present, sample intervals, organic vapor, field screening measurements, and a qualitative indication of soil conditions. The entire length of each boring will be logged using the Unified Soil Classification System (USCS) and screened for organic vapors using a PID. Any qualitative visual signs of potential contamination (such as soil staining, elevated PID, or odors) will be noted on soil sample log sheets and on the boring log.

Concerning IDW, only nominal excess soil is expected to be generated from hand augering and will be placed back in the boring rather than containerized. Drill cuttings (soil) from monitoring well installation will be containerized and managed as IDW as discussed below and in SOP 04 (Decontamination of Field Equipment, Appendix A).

Surface and Subsurface Soil Incremental Sampling

ISM was established for select DUs (DUs 1, 2, 3, and 4) by collecting numerous increments of soil (typically 30–100 increments) that are combined into a manageable volume of approximately 1 to 2 kilograms, processed, and subsampled according to specific protocols on ISM (Interstate Technology Regulatory Council [ITRC], 2012). ISM surface (0- to 3-inches bgs) soil and subsurface (3 to 18 inches bgs, DU1 only) soil samples will be collected in accordance with SOP-05 (incremental Sampling (IS) Methodology for Soil and/or Sediment for the Military Munitions Response Program, Appendix A) and using guidance from the ITRC (2012). Each ISM sample will consist of multiple increments from multiple sampling units (SUs) or grids for a given DU as described below and in Worksheets #s 17 and 18. ISM sample strategy is depicted in Figures 14-1 through 14-6. ISM samples will be collected using a core tool

specifically designed to collect ISM samples in cohesive soil, where possible. In addition, the core tool diameter will be determined based on the number of increments required and the goal volume of 1 to 2 kilograms per sample. If the recommended core barrel size, per the table in SOP-05, is not available, multiple adjacent plugs (increments) may be collected using a smaller size core to enable collection of the appropriate increment volume from each increment location. If unconsolidated soil is encountered, disposable or stainless steel scoops may be used. If a subsurface anomaly is identified by the UXO Escort, the increment location is to be moved to the nearest area clear of subsurface anomalies within the same increment grid or SU. Because the number and location of increments are dependent on following Anomaly Avoidance and numerous subsurface anomalies are expected, the number shown may not be achievable.

Replicate Sample Collection

Replicate samples will be collected for each DU. Replicate samples are not field splits (duplicates); rather, they are independently collected samples with unique increments selected from within the DU or SU with a unique blind sample number, denoted by and R1, R2, or R3 in the sample location and sample ID (see Worksheets #s 17 and 18). ISM samples and their blind replicates will be collected using a DU-specific systematic random sampling design and depicted in Figures 14-1 through 14-6.

- Two replicate samples will be collected in DU1 of the surface soil exposure unit (0 to 3 inches), resulting in a triplicate (see Figure 14-1).

- One replicate sample will be collected in DU1 of the subsurface soil exposure unit (3 to 18 inches) (see Figure 14-1).

- One blind replicate sample will be collected in DU2A-a and DU2A-b of the surface soil exposure unit (0 to 3 inches) resulting in a duplicate (see Figure 14-2).

- Three replicates (four samples total) will be collected in DU2B through F, for each ISM sample of the surface soil exposure unit (0 to 3 inches) (see 14-3, 14-4, and 14-5).

- Two replicate samples will be collected in DU3-a and DU3-b of the surface soil exposure unit (0 to 3 inches), resulting in a triplicate for both DU3-a and DU3-b (see Figure 14-6).

- Two replicate samples will be collected in DU4 of the surface soil exposure unit (0 to 3 inches), resulting in a triplicate (see Figure 14-6).

Concerning IDW, no excess soil is expected to be generated from ISM activities.

Pond Characterization and Sediment Sampling (Pond)

Characterization of surface water in the pond to aid in planning the future MEC RI SAP will include inspection of the pond for evidence of surface inflows/outflows, collection of pond depth measurements to calculate the estimated volume of water in the pond, and collection of a single grab surface water sample to aid determination of possible discharge scenarios. A survey of perimeter of the pond for inflows and outflows of the pond will be performed, any identified flows will be photographed, and location coordinates of each flow will be collected using a GPS. A surface water sample will be collected prior to any contact with the sediment bottom, with the exception of accessing the pond to avoid elevated turbidity in the sample. Grab surface water sample(s) will be collected following determination of water depth and collection of water temperature readings every foot in the water column to determine if the water column is stratified. If the water column is stratified, collect two grab samples from both temperature zones at a central location in the pond. If the water column is not stratified, collect one grab surface water sample from central location in the pond and over the entire length of the water column. Surface water sample must be collected prior to sediment samples to reduce potential turbidity in the sample. The sample will be analyzed in the field for total dissolved solids, specific conductance, pH, temperature, and dissolved oxygen and in the laboratory for explosives, TAL metals, VOCs, SVOCs, and EPH/VPH. The surface water sample will be collected in accordance with SOP-06 (Surface Water and Sediment Sampling, Appendix A). Depth measurements will be collected using a staff gauge, weighted tape measure, or equivalent and coordinates for each location will be collected using a GPS.

Four surface and four subsurface collocated sediment sampling locations are spread out along more or less equal distance along the historical center-line of the pond. One surface sediment sample will be collected just before the culvert south of the pond near Old Gurnet Road, which appears to be an intermittent discharge location for Site 12. Sediment samples will be collected following SOP-06 (Surface Water And Sediment Sampling, Appendix A) and using a 20- by 2- inch Wildco Hand Core Sampler, or equivalent, with a dedicated acetate liner. Sediment thickness will be determined by pushing the sampling device with a one-handed push to refusal, where able, and using a core cap to close the sampling device allowing for the measurement and logging of the sediment. At shallow locations, samples may be collected by pushing the acetate liner tube directly into the sediment. A dedicated sample catch basket will be used at several locations to keep the sample from falling out of the acetate liner. Sample materials will be collected from 0 to 6 inch interval below the sediment surface and 6 to 12 inch interval below the sediment surface, if available. The 6 to 12 inch interval may be adjusted based on

visual and olfactory observations (PID) in deeper sediment. Sediment intervals may not be attainable if a bedrock ledge is present and the vertical boundary based on actual site conditions may be smaller than the proposed sample intervals. For each of the four sample locations up to three attempts will be made to relocate the sample if no sediment is present, moving approximately 5 feet along the pond centerline. Moreover, it is recognized that sediment thickness may only be a few inches so a clamshell dredge will alternatively be used as necessary in accordance with SOP-06 (Surface Water and Sediment Sampling, Appendix A). The VOC fraction of the sample will be taken out of the first core collected, and then additional cores may be collected until there is sufficient sample volume for the remaining fractions. Samples will be homogenized, decanted if necessary, and transferred into appropriate bottleware. One sample log sheet will be completed for each sediment sample collected (included in Appendix A).

Geologic and Geophysical Surveying (VLF/EM and GPR)

A desktop fracture trace analysis and brief field investigation of bedrock exposures near Site 12 will be performed to collected strike and dip measurements of faults and fractures to identify the predominant fracture directions at the site. In addition, an equal area stereonet will be prepared to determine the dip direction and magnitude associated with the predominant fracture directions.

A VLF geophysical survey will be attempted at 25-foot-spaced data stations on 25-foot-spaced parallel survey lines in both north-south and east-west orientations across DU2 and up to 100 feet beyond its boundary. The VLF survey is being used to search for conductive fractures (water-filled fractures) in the DU2 area. Recently, a vital VLF transmitting station located in Cutler, Maine, required to perform many VLF surveys on the East Coast, was not operational for several days. If not operational, it may be possible use a different VLF station (i.e., Seattle); however, if the VLF survey antenna cannot obtain sufficient survey signal strength, a different EM technique may be substituted for VLF. The substituted technique will use multi-frequency EM surveying. Data from this EM survey will be collected along 10-foot-spaced parallel survey lines in one direction across the DU2 overall berm area.

Finally, a focused GPR survey is planned at possible conductive fracture locations interpreted from VLF or EM data (whichever is performed) and fracture trace analysis. GPR data will be collected along 5-foot-spaced survey lines across interpreted as possible fracture locations for the purposes of searching for possible shallow bedrock fractures.

Monitoring Well Drilling and Installation

Three shallow groundwater monitoring wells will be installed in accordance with SOP-07 (Groundwater Monitoring Well Installation, Appendix A). Monitoring wells are proposed to be installed within DU6 at locations to intersect shallow groundwater based on the results of the 2003 bedrock geology investigation and the planned geologic and geophysical surveying described above. One or more monitoring wells may be bedrock wells depending on site conditions, but the total depth of each well is limited to 30 feet bgs. USEPA and MEDEP will be involved in determining monitoring well locations following the availability of geophysical surveying investigation results. Procedures for drilling and logging a boring in rock are included in SOP-08 (Soil and Rock Drilling Methods, Appendix A). A boring log and well construction sheet will be produced for each well.

Wells will be installed using drive and wash drilling techniques using a temporary 4-inch casing, which enables split spoon soil sampling ahead of the casing and seating the casing in the top of rock, followed by installing a borehole in rock using HQ wire-line coring without removing the temporary casing. The HQ size will be of sufficient diameter (approximately 3 7/8-inch) to install a 2-inch-diameter monitoring well. Permanent monitoring wells will be constructed of 2-inch-diameter, Schedule 40, flush-joint, polyvinyl chloride (PVC) riser pipe and slotted screen (see SOP-07, Monitoring Well Installation, Appendix A). In each well, the screen will be 10 feet long and have a slot size of 0.010 inch (factory slotted). All monitoring wells will be stickup wells with protective casings.

A primary filter pack of clean silica sand will be installed flush with the bottom of the well to a minimum of 24 inches above the top of the 10-foot-long well screen. Wells installation will allow for a minimum 2-inch-thick sand pack in the annulus between all sides of each new well and the sidewalls of the borehole. Monitoring wells will be installed upon completion of the borings. A sand passing U.S. Standard Sieve No. 20/40 will be used for fine/silty sand formations (0.010-inch slot size). A minimum 24-inch-thick seal of 100-percent bentonite pellets will be installed above the primary filter pack and allowed to hydrate in accordance with the manufacturer's recommendations. A concrete pad (minimum of 6-inch thickness and 3 feet by 3 feet square) will be installed above the bentonite seal and around the casing. The stick-up well will be constructed using a 6-inch steel protective case with a locking cap. A boring log and well construction sheet will be produced for each new well. Cuttings will be containerized and managed as IDW as discussed below and in SO-04 (Decontamination of Field Equipment, Appendix A). Augers and other well drilling equipment will be decontaminated prior to the start of drilling, between each soil boring and well installed, and prior to demobilization from the site.

Well Surveying

Newly installed monitoring wells will be surveyed for horizontal locations and vertical elevations by a Maine-licensed surveyor. The ground surface, the top of the protective casing, and the top of each well riser will be surveyed. In addition, a staff guage located in the pond will also be surveyed. Horizontal locations will be surveyed to 0.1 foot, and vertical elevations will be surveyed to 0.01 foot. Horizontal coordinates will be relative to NAD 83 Maine State Plane Coordinate System (West Zone) in US Survey Feet, and elevations will be relative to the NAVD of 1988.

Well Development

All new monitoring wells will be developed in accordance with SOP-07 (Groundwater Monitoring Well Installation, Appendix A) to remove fine sediment from inside and around the well screens, no sooner than 24 hours after well completion. Wells will be developed by surging and bailing or pumping, as determined in the field.

Measurements of pH, temperature, turbidity, DO, ORP, and specific conductance will be collected during development. A minimum of three times the standing water volume in the well casing will be removed. An attempt will be made to develop the well to a turbidity of 10 nephelometric turbidity units (NTUs) or less. The wells will be developed until the discharge water is visibly clear or if the target turbidity cannot be achieved (10 NTUs), development will continue until the field parameters have stabilized. Water quality measurements and volumes removed will be recorded for each well on the well development form. A blank copy is provided in Appendix A. The completed well development forms will be included in the RI Report.

Water-Level Measurements

Prior to sampling, one synoptic round of depth to water level and total well depth measurements will be obtained at all new monitoring wells and a surface water gauge installed along the west-central side of the pond. All groundwater level measurements will be taken within a 2-hour period using an electronic water level meter and no sooner than 24 hours after a significant precipitation event to minimize precipitation effects on the data. Water level measurements will be recorded to within 0.01-foot accuracy from a marked reference point on the well riser pipe. Detailed procedures regarding water level measurements are included in SOP-09 (Evaluation of Existing Monitoring Wells and Water Level Measurement, Appendix A). Water levels will be recorded on the groundwater level measurement form provided in SOP-09. The water level meter will be decontaminated between each well measurement; decontamination procedures are addressed in SOP-04.

Low-Flow Purging and Groundwater Sampling of Monitoring Wells

Groundwater samples will be collected from monitoring wells using low-flow techniques no sooner than 48 hours following development in accordance with Tetra Tech SOP-01 and SOP-10 (Groundwater Sample Acquisition and Onsite Water Quality Test and Non-Radiological Sample Handling Appendix A). In accordance with these SOPs, pH, temperature, ORP, DO, turbidity, specific conductance, water level, and flow rate will be measured during purging and recorded on sample log sheets. The wells will be developed until water quality parameters have stabilized, as indicated below.

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

If the target turbidity cannot be reached (10 NTUs), then development will continue until turbidity has stabilized. Water quality measurements and volumes removed will be recorded for each well on the well development form. A blank copy of this form is provided in Appendix A. The completed well development forms will be included in the RI Report.

GPS Locating

A hand held Trimble GPS, or other equivalent unit, unit will be used to locate all discrete soil, and sediment sampling points and geologic measurement locations in accordance with SOP-11 (Data Collection and Transfer, Appendix A). Integrated differential GPS (DGPS) measurements are planned to locate the EM data during the geophysical surveys. The GPS equipment will be checked on control monuments before and after each day's use, and these checks will be documented in the field notebook. The GPS survey instrument will be closely monitored during field acquisition by using Dilution of Precision (DOP) criteria, or the number of satellite signals received criteria). DOP should normally be less than three to obtain high-quality results, and ideally four satellites should indicate high-quality results, although the actual number may be more limited based on site conditions at the time. If the DOP and number of satellites are not adequate to collect high-quality results, a tape measure and compass may be used to measure locations from a surveyed point (such as the corner of the concrete pad or a well).

A new reference grid system does not need to be developed because the established 100-foot by 100-foot grid used during the previous MEC investigations will be used to determine the boundaries of DUs and SUs. For ISM soil samples each sample collection station (1 through 10) along the face of existing berm will be documented with a GPS with sub-meter accuracy (or better). For ISM soil samples from DUs 2 through 4, the four corners of the required SU grids will be documented with a GPS with sub-meter accuracy (or better).

IDW Management

Waste solids (soil and sediment) will be generated during installation of soil/sediment borings and monitoring wells. The IDW will consist of excess cuttings from hand-augured borings that were not collected for laboratory analyses, which are nominal and will be placed back in the boring. In addition, IDW will consist of excess cuttings produced during drilling of boreholes for monitoring well installation, which are much greater in volume and the associated soils will be containerized and sampled while associated rock cuttings will be placed on the ground surface near the given monitoring well. The waste solids from sediment sampling will be containerized.

Wastewater will be generated during groundwater sampling, well development, sampling of monitoring wells, and decontamination procedures. Aqueous IDW will be containerized in Department of Transportation (DOT)-approved (DOT specification 17C) 55-gallon drums and stored in the centralized location during the field activities. The drums will be labeled as soon as possible after they are filled and will be arranged into rows by the drilling subcontractor(s) (no more than two drums deep) segregated by liquids and contaminated personal protective equipment (PPE) for easy access. IDW associated with containerized drill cuttings will be analyzed for Toxicity Characteristic Leaching Procedure (TCLP) Organics and TCLP Inorganics, and other waste characterization parameters as listed in Worksheet #15 to determine disposal requirements. All aqueous IDW will be containerized pending waste characterization analyses for the same analytical suite as the groundwater samples. Drums will be stored on pallets and clean prior to moving them to the centralized storage area. Based on the results of the waste characterization the IDW will be transported and appropriately disposed of off-site at a Navy-approved disposal facility.

Field Decontamination Procedures

Decontamination of sampling equipment will not be necessary for dedicated and disposable hand trowels. Decontamination of reusable sampling equipment (non-disposable hand trowels, hand augers, split-spoon-samplers, drill rods and bits, sediment corer, or groundwater sampling equipment) will be

conducted prior to sampling and between samples at each location. Decontamination fluids will be containerized and characterized for appropriate disposal with other IDW. Decontamination of equipment will be conducted according to the sequence established in SOP-04 (Decontamination of Field Equipment, Appendix A).

Field Documentation Procedures

To ensure detailed and accurate documentation of field activities, which is necessary to ensure data integrity, authenticity, and defensibility, Tetra Tech SOP-12 (Field documentation, Appendix A) for sample documentation, handling, tracking, and custody will be followed.

The principal data generated for this project will be from field personnel. Field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity.

Sample Handling

After samples have been collected, they will be held on ice and sent to the appropriate analytical laboratory within a reasonable time depending on the analyte holding time. The shipment of samples to the laboratory will be made via an overnight shipping courier service (e.g., FedEx) following SOP-10 (Non-Radiological Sample Handling, Appendix A). Sample containers will be provided certified clean (I-Chem 300 or equivalent) from the analytical laboratory. Sample labeling will be in accordance with Worksheet #14, and the sample numbering scheme will be in accordance with Worksheet #18. The selection of sample containers and the sample preservation, packaging, and shipping will be in accordance with Worksheet #19 and SOP-04 (Sample Preservation, Packaging, and Shipping) and SOP-13 (Sample Nomenclature) (Appendix A).

Quality Control Tasks

QA/QC samples will be collected at frequencies listed in Worksheet #12.

14.2 ANALYTICAL AND REPORTING PROJECT TASKS

Additional project-related tasks include:

- Analytical tasks
- Data management
- Assessment and oversight
- Data review
- Project reports

Analytical Tasks

Chemical analyses for explosives, VOCs, SVOCs, EPH/VPH, and TAL metals will be performed by Katahdin, Scarborough, Maine, which is a DoD Environmental Laboratory Approval Program (ELAP)-accredited laboratory for the target analytes and analytical groups that will be reported by them. TestAmerica will perform analysis of perchlorate in groundwater. Analytical Laboratory Services, Inc. (ALS), in Middletown, Pennsylvania, will perform the laboratory grinding preparation step for ISM samples submitted for explosives analysis in accordance with SW-846 Method 8330B Appendix A as a subcontract laboratory to Katahdin. ALS is DoD ELAP accredited to perform the explosives grinding. Copies of these laboratory's certifications and ELAP accreditations are provided in Appendix C. Analyses will be performed in accordance with the analytical methods identified in Worksheet #30. Katahdin and TestAmerica will meet the PSLs specified in Worksheet #15 and will perform the chemical analyses following laboratory-specific SOPs (see Worksheet #s 19 and 23) developed based on the methods listed in Worksheet #s 19 and 30.

The Katahdin, TestAmerica, and ALS QAMs will ensure that all laboratory SOPs were followed and will verify that all method QC samples were analyzed and in control, as listed in the analytical SOPs. If method QA is not in control, the Katahdin and TestAmerica QAM, as appropriate, will contact the Tetra Tech PM for guidance real time as problems arise. Results will be reported in each analytical data package and electronic data deliverable (EDD). This information will also be included in the project database that will eventually be uploaded to the Naval Installation Restoration Information Solution (NIRIS). In addition, data will be supplied to MEDEP in the approved data format.

All soil and sediment results will be reported by the laboratory on an adjusted dry-weight basis. Results of percent moisture will be reported in each analytical data package and associated electronic data files. This information will also be added to the project database, which will eventually be uploaded to the NIRIS database. Percent moisture information will also be included in the RI Report.

The analytical data packages provided by Katahdin will be in a Contract Laboratory Program (CLP)-like format and will be fully validatable and contain raw data, summary forms for all sample and laboratory method blank data, and summary forms containing all method-specific QC information [results, percent recoveries (%Rs), RPDs, RSDs, and/or Percent Differences or percent drifts (%Ds), etc.].

Data Generation Procedures:

Project documentation and records include the following:

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

Data recording formats are described in Worksheet #27.

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

Assessment and Oversight: Refer to Worksheet #32 for assessment findings and CAs and to Worksheet #33 for QA management reports.

Data Review: Data verification is described in Worksheet #34, data validation is described in Worksheet #s 35 and 36, and usability assessment is described in Worksheet #37.

Project Report: A preliminary draft report will first be prepared for Navy review. Subsequently, draft and final versions of project report will be prepared and submitted to USEPA and MEDEP for review. The report will include the following sections:

- Executive Summary – will include a brief description of the work conducted and the findings.

- Introduction and Background – will include a description of the history of operations and activities at the site and a summary of any previous investigations and removal actions.

- Description of Field Investigations – will include a summary of the work performed in accordance with the approved UFP-SAP and any field modifications as documented by the Tetra Tech FOL. This section will include maps showing the sampling locations, geologic fracture trace and geophysics results (if conducted) and tables summarizing the data collected.

- Data Quality – will include a summary of quantitative analytical performance indicators such as completeness, precision, bias, and sensitivity as well as qualitative indicators such as representativeness and comparability. This section will include a reconciliation of project data with the DQOs and an identification of deviations from this UFP-SAP.

  A data usability assessment will be used to identify significant deviations in analytical performance that could affect the ability to meet project objectives. The elements of this review are presented in Worksheet #37.

- Nature and Extent of Contamination – will include a discussion of the contamination found in each medium sampled in relation to the CSM of the site. Detected contaminant concentrations will be tabulated for each medium and depicted on maps.

- Contaminant Fate and Transport – will include a description of the contaminants detected and their behavior in the soil, bedrock, sediment, and groundwater, particularly with emphasis on the future migration of these contaminants to any possible exposure areas.

- Ecological and Human Health Risk Assessments - will be prepared in accordance with methodologies presented in Appendices D and E, respectively.

- Summary and Conclusions – will include a summary of the findings, a conclusion assessing whether delineation of contamination is adequate, and a recommendation for further investigations if needed.

Tetra Tech will submit the draft report and respond to comments received on the draft report before any additional sampling begins. The final version of the report will submitted in hardcopy and electronic format to the project stakeholders.

Data Management

The principal data generated for this project will be field and laboratory analytical data. After the RI is completed, field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after the completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity.

The data handling procedures to be followed by the laboratories will meet the requirements of the technical specifications. Electronic data results will be automatically downloaded into the Tetra Tech database in accordance with proprietary Tetra Tech processes.

The Tetra Tech PM (or designee) is responsible for the overall tracking and control of data generated for the project, which includes the following:

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

- **Data Storage, Archiving, and Retrieval**. The data packages received from the laboratory are tracked in the data validation logbook. After the data are validated, the data packages are entered into the Tetra Tech Navy CLEAN file system and archived in secure files. The field records including field logbooks, sample logs, chain-of-custody records, and field calibration logs will be submitted by the Tetra Tech FOL to be entered into the Navy CLEAN file system prior to archiving in secure project files. The project files are audited for accuracy and completeness. At the completion of the Navy contract, the records will be stored by Tetra Tech. Electronic data will be uploaded to NIRIS as indicated in Worksheet #29.

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

- **Electronic Data.** All electronic data will be compiled into a NIRIS Electronic Data Deliverable (NEDD) and loaded into NIRIS. Low-flow parameter measurements and water levels will be included in the MEDEP EDD.

Assessment and Oversight

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

Data Review

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

SAP Worksheet #15a -- Reference Limits and Evaluation Table - Soil

Project screening-level support documentation is provided in Appendix B.

(UFP-QAPP Manual Section 2.8.1)

Chemical	Chemical Abstract Service(CAS) No.	Human Health (HH) PSL (mg/kg)	HH PSL Reference	Ecological PSL (mg/kg)	Ecological PSL Reference	Minimum PSL (mg/kg)	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
TARGET ANALYTE LIST METALS										
ALUMINUM	7429-90-5	7700	EPA RSL	50	ORNL Plant	50	16.7	30	4	0.51
ANTIMONY	7440-36-0	3.1	EPA RSL	0.27	EPA SSL Wildlife	0.27	0.09	0.1	0.05	0.02
ARSENIC	**7440-38-2**	**0.39**	**EPA RSL**	**18**	**EPA SSL Plant**	**0.39**	**0.13**	**0.5**	**0.4**	**0.15**
BARIUM	7440-39-3	1500	EPA RSL	330	EPA SSL Invert	330	110	0.2	0.1	0.037
BERYLLIUM	7440-41-7	16	EPA RSL	10	ORNL Plant	10	3.3	0.1	0.02	0.0041
CADMIUM	7440-43-9	7	EPA RSL	0.36	EPA SSL Wildlife	0.36	0.12	0.1	0.02	0.0076
CALCIUM	7440-70-2	NC	None	NC	None	NC	NC	10	8	3.83
CHROMIUM[1]	**7440-47-3**	**0.29**	**EPA RSL**	**0.4**	**ORNL Invert**	**0.29**	**0.1**	**0.4**	**0.3**	**0.05**
COBALT	7440-48-4	2.3	EPA RSL	13	EPA SSL Plant	2.3	0.8	0.1	0.03	0.0054
COPPER	7440-50-8	310	EPA RSL	28	EPA SSL Wildlife	28	9.3	0.3	0.2	0.071
IRON	7439-89-6	5500	EPA RSL	200	ORNL Invert	200	66.7	10	6	2.4
LEAD	7439-92-1	400	EPA RSL	11	EPA SSL Wildlife	11	3.7	0.1	0.05	0.007
MERCURY	7439-97-6	1	EPA RSL	0.1	ORNL Invert	0.1	0.033	0.033	0.017	0.0052
MAGNESIUM	7439-95-4	NC	None	NC	None	NC	NC	10	8	1.37
MANGANESE	7439-96-5	180	EPA RSL	220	EPA SSL Plant	180	60	0.2	0.1	0.042
NICKEL	7440-02-0	150	EPA RSL	38	EPA SSL Plant	38	12.7	0.2	0.12	0.026
POTASSIUM	7440-09-7	NC	None	NC	None	NC	NC	100	40	4.6
SELENIUM	7782-49-2	39	EPA RSL	0.52	EPA SSL Plant	0.52	0.17	0.5	0.3	0.039
SILVER	7440-22-4	39	EPA RSL	4.2	EPA SSL Wildlife	4.2	1.4	0.1	0.04	0.0066
SODIUM	7440-23-5	NC	None	NC	None	NC	NC	100	40	2.6
THALLIUM	**7440-28-0**	**0.078**	**EPA RSL**	**0.0569**	**Region 5 Wildlife**	**0.0569**	**0.019**	**0.1**	**0.04**	**0.0094**
VANADIUM[2]	7440-62-2	39	EPA RSL	2	ORNL Plant	2	0.67	0.5	0.4	0.11
ZINC	7440-66-6	2300	EPA RSL	46	EPA SSL Wildlife	46	15.3	1	0.8	0.13
TARGET COMPOUND LIST VOLATILE ORGANIC COMPOUNDS										
1,1- DICHLOROETHANE	75-34-3	3.3	EPA RSL	0.02	Target Value	0.02	0.007	0.005	0.0025	0.0017
1,1,1-TRICHLOROETHANE	71-55-6	870	EPA RSL	0.07	Target Value	0.07	0.02	0.005	0.0025	0.00042
1,1,2- TRICHLOROETHANE	79-00-5	0.16	EPA RSL	0.4	Target Value	0.16	0.05	0.005	0.0025	0.00097
1,1,2,2- TETRACHLORETHANE	79-34-5	0.56	EPA RSL	0.127	Region 5 Wildlife	0.127	0.04	0.005	0.0025	0.00084
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	76-13-1	4300	EPA RSL	NC	NC	4300	1400	0.005	0.0025	0.0009
1,1-DICHLOROETHENE	75-35-4	24	EPA RSL	0.1	Target Value	0.1	0.03	0.005	0.0025	0.00093
1,2- DICHLOROBENZENE	95-50-1	190	EPA RSL	2.96	Region 5 Wildlife	2.96	0.99	0.005	0.0025	0.00078
1,2- DICHLOROETHANE	107-06-2	0.43	EPA RSL	0.02	Target Value	0.02	0.007	0.005	0.0025	0.001
1,2,3-TRICHLOROBENZENE	87-61-6	4.9	EPA RSL	20	ORNL Invert	4.9	1.6	0.005	0.0025	0.00076
1,2,4-TRICHLOROBENZENE	120-82-1	6.2	EPA RSL	11.1	Region 5 Wildlife	6.2	2.1	0.005	0.0025	0.00079
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	0.0054	EPA RSL	0.0352	Region 5 Wildlife	0.0054	0.002	0.005	0.0025	0.0015

Chemical	Chemical Abstract Service(CAS) No.	Human Health (HH) PSL (mg/kg)	HH PSL Reference	Ecological PSL (mg/kg)	Ecological PSL Reference	Minimum PSL (mg/kg)	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
1,2-DIBROMOETHANE	106-93-4	0.034	EPA RSL	1.23	Region 5 Wildlife	0.034	0.01	0.005	0.0025	0.0012
1,2-DICHLOROPROPANE	**78-87-5**	**0.94**	**EPA RSL**	**0.002**	**Target Value**	**0.002**	**0.00067**	**0.005**	**0.0025**	**0.0014**
1,3-DICHLOROBENZENE	541-73-1	NC	None	37.7	Region 5 Wildlife	37.7	12.6	0.005	0.0025	0.00062
1,4- DICHLOROBENZENE	106-46-7	2.4	EPA RSL	0.546	Region 5 Wildlife	0.546	0.18	0.005	0.0025	0.00044
2-BUTANONE	78-93-3	2800	EPA RSL	89.6	Region 5 Wildlife	89.6	29.9	0.025	0.0125	0.0059
2-HEXANONE	591-78-6	21	EPA RSL	12.6	Region 5 Wildlife	12.6	148	0.025	0.0125	0.0048
4-METHYL-2-PENTANONE	108-10-1	530	EPA RSL	443	Region 5 Wildlife	443	148	0.025	0.0125	0.0059
ACETONE	67-64-1	6100	EPA RSL	2.5	Region 5 Wildlife	2.5	0.83	0.025	0.0125	0.0051
BENZENE	71-43-2	1.1	EPA RSL	25	CCME Wildlife	1.1	0.37	0.005	0.0025	0.00092
BROMOCHLOROMETHANE	74-97-5	16	EPA RSL	NC	NC	16	5.3	0.005	0.0025	0.00091
BROMODICHLOROMETHANE	75-27-4	0.27	EPA RSL	0.54	Region 5 Wildlife	0.27	0.09	0.005	0.0025	0.0006
BROMOFORM	75-25-2	62	EPA RSL	15.9	Region 5 Wildlife	15.9	5.3	0.005	0.0025	0.0007
BROMOMETHANE	74-83-9	0.73	EPA RSL	0.235	Region 5 Wildlife	0.235	0.078	0.005	0.0025	0.0011
CARBON DISULFIDE	75-15-0	82	EPA RSL	0.0941	Region 5 Wildlife	0.0941	0.032	0.005	0.0025	0.00078
CARBON TETRACHLORIDE	56-23-5	0.61	EPA RSL	2.98	Region 5 Wildlife	0.61	0.2	0.005	0.0025	0.0013
CHLOROBENZENE	108-90-7	29	EPA RSL	0.03	Target Value	0.03	0.01	0.005	0.0025	0.00051
CHLOROETHANE	75-00-3	1500	EPA RSL	NC	None	1500	500	0.005	0.0025	0.0013
CHLOROFORM	67-66-3	0.29	EPA RSL	1.19	Region 5 Wildlife	0.29	0.097	0.005	0.0025	0.00035
CHLOROMETHANE	74-87-3	12	EPA RSL	10.4	Region 5 Wildlife	10.4	3.6	0.005	0.0025	0.0014
CIS-1,2- DICHLOROETHENE	156-59-2	16	EPA RSL	0.2	Target Value	0.2	0.067	0.005	0.0025	0.00091
CIS-1,3- DICHLOROPROPENE[3]	10061-01-5	1.7	EPA RSL	0.2	Target Value	0.2	0.067	0.005	0.0025	0.00072
CYCLOHEXANE	110-82-7	700	EPA RSL	NC	None	700	233	0.005	0.0025	0.0014
DIBROMOCHLOROMETHANE	124-48-1	0.68	EPA RSL	2.05	Region 5 Wildlife	0.68	0.23	0.005	0.0025	0.001
DICHLORODIFLUOROMETHANE	75-71-8	9.4	EPA RSL	39.5	Region 5 Wildlife	9.4	3.1	0.005	0.0025	0.00092
ETHYLBENZENE	100-41-4	5.4	EPA RSL	5.16	Region 5 Wildlife	5.16	1.7	0.005	0.0025	0.00065
ISOPROPYLBENZENE	98-82-8	210	EPA RSL	NC	None	210	70	0.005	0.0025	0.00092
METHYL ACETATE	79-20-9	7800	EPA RSL	NC	None	7800	2600	0.005	0.0025	0.0027
METHYL TERT-BUTYL ETHER	1634-04-4	43	EPA RSL	NC	None	43	14.3	0.005	0.0025	0.0011
METHYLCYCLOHEXANE	108-87-2	NC	None	NC	NC	NA	NA	0.005	0.0025	0.00096
METHYLENE CHLORIDE	75-09-2	36	EPA RSL	NC	None	36	12	0.005	0.0025	0.0079
STYRENE	100-42-5	630	EPA RSL	1.2	LANL Invert	1.2	0.4	0.005	0.0025	0.00051
TETRACHLOROETHENE	**127-18-4**	**8.6**	**EPA RSL**	**0.002**	**Target Value**	**0.002**	**0.00067**	**0.005**	**0.0025**	**0.0012**
TOLUENE	108-88-3	500	EPA RSL	75	CCME	75	25	0.005	0.0025	0.0014
O-XYLENE	95-47-6	69	EPA RSL	0.2	Target Value	0.2	0.067	0.005	0.0025	0.0013
m,p-XYLENE	108-38-3	59	EPA RSL	0.2	Target Value	0.2	0.067	0.005	0.0025	0.0017
TOTAL XYLENES	1330-20-7	63	EPA RSL	NC	None	63	21	0.015	0.0075	0.0013
TRANS-1,2- DICHLOROETHENE	156-60-5	15	EPA RSL	0.2	Target Value	0.2	0.07	0.005	0.0025	0.00071
TRANS-1,3-DICHLOROPROPENE[3]	10061-02-6	1.7	EPA RSL	0.2	Target Value	0.2	0.07	0.005	0.0025	0.00086
TRICHLOROETHENE	79-01-6	0.44	EPA RSL	0.1	Target Value	0.1	0.03	0.005	0.0025	0.00059
TRICHLOROFLUOROMETHANE	75-69-4	79	EPA RSL	16.4	Region 5 Wildlife	16.4	5.5	0.005	0.0025	0.00091
VINYL CHLORIDE	75-01-4	0.06	EPA RSL	0.01	Target Value	0.01	0.003	0.005	0.0025	0.00087

Chemical	Chemical Abstract Service(CAS) No.	Human Health (HH) PSL (mg/kg)	HH PSL Reference	Ecological PSL (mg/kg)	Ecological PSL Reference	Minimum PSL (mg/kg)	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
TARGET COMPOUND LIST SEMI-VOLATILE ORGANIC COMPOUNDS										
1,1'-BIPHENYL	92-52-4	5.1	EPA RSL	60	ORNL Plant	5.1	1.7	0.33	0.248	0.073
1,4-DIOXANE*	123-91-1	4.9	EPA RSL	2.05	Region 5 Wildlife	2.05	0.68	0.1	0.05	0.0011
1,2,4,5-TETRACHLOROBENZENE	95-94-3	1.8	EPA RSL	2.02	Region 5 Wildlife	1.8	0.6	0.33	0.248	0.135
2,2-OXYBIS(1-CHLOROPROPANE)	108-60-1	4.6	EPA RSL	19.9	Region 5 Wildlife	4.6	1.5	0.33	0.248	0.089
2,3,4,6-TETRACHLOROPHENOL	**58-90-2**	**180**	**EPA RSL**	**0.199**	**Region 5 Wildlife**	**0.199**	**0.06**	**0.33**	**0.248**	**0.14**
2,4,5-TRICHLOROPHENOL	95-95-4	610	EPA RSL	4	ORNL Plant	4	1.3	0.82	0.615	0.155
2,4,6-TRICHLOROPHENOL	88-06-2	6.1	EPA RSL	9.94	Region 5 Wildlife	6.1	2	0.33	0.248	0.155
2,4-DICHLOROPHENOL	120-83-2	18	EPA RSL	87.5	Region 5 Wildlife	18	6	0.33	0.248	0.15
2,4-DIMETHYLPHENOL	105-67-9	120	EPA RSL	NC	None	120	40	0.33	0.248	0.165
2,4-DINITROPHENOL	**51-28-5**	**12**	**EPA RSL**	**0.0609**	**Region 5 Wildlife**	**0.0609**	**0.02**	**0.82**	**0.615**	**0.377**
2,4-DINITROTOLUENE	121-14-2	1.6	EPA RSL	1.28	Region 5 Wildlife	1.28	0.43	0.33	0.248	0.085
2,6-DINITROTOLUENE	**606-20-2**	**6.1**	**EPA RSL**	**0.0328**	**Region 5 Wildlife**	**0.0328**	**0.011**	**0.33**	**0.248**	**0.079**
2-CHLORONAPHTHALENE	**91-58-7**	**630**	**EPA RSL**	**0.0122**	**Region 5 Wildlife**	**0.0122**	**0.004**	**0.33**	**0.248**	**0.087**
2-CHLOROPHENOL	**95-57-8**	**39**	**EPA RSL**	**0.243**	**Region 5 Wildlife**	**0.243**	**0.081**	**0.33**	**0.248**	**0.164**
2-METHYLNAPHTHALENE*	91-57-6	23	EPA RSL	29	EPA SSL Invert	23	7.7	0.02	0.01	0.0017
2-METHYLPHENOL	**95-48-7**	**310**	**EPA RSL**	**0.05**	**Target Value**	**0.05**	**0.017**	**0.33**	**0.248**	**0.2**
2-NITROANILINE	88-74-4	61	EPA RSL	74.1	Region 5 Wildlife	61	20.3	0.82	0.615	0.075
2-NITROPHENOL	88-75-5	NC	None	1.6	Region 5 Wildlife	1.6	0.53	0.33	0.248	0.167
3,3'-DICHLOROBENZIDINE	91-94-1	1.1	EPA RSL	0.646	Region 5 Wildlife	0.646	0.21	0.33	0.248	0.114
3-NITROANILINE[4]	99-09-2	24	EPA RSL	3.16	Region 5 Wildlife	3.16	1	0.82	0.615	0.094
4,6-DINITRO-2-METHYLPHENOL	**534-52-1**	**0.49**	**EPA RSL**	**0.144**	**Region 5 Wildlife**	**0.144**	**0.048**	**0.82**	**0.615**	**0.337**
4-BROMOPHENYL-PHENYLETHER	101-55-3	NC	None	NC	None	NC	NC	0.33	0.248	0.085
4-CHLORO-3-METHYLPHENOL	59-50-7	610	EPA RSL	7.95	Region 5 Wildlife	7.95	2.6	0.33	0.248	0.166
4-CHLOROANILINE	106-47-8	2.4	EPA RSL	1	LANL Plant	1	0.33	0.33	0.248	0.119
4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	NC	None	NC	None	NC	NC	0.33	0.248	0.078
4-METHYLPHENOL	**106-44-5**	**610**	**EPA RSL**	**0.05**	**Target Value**	**0.05**	**0.017**	**0.33**	**0.248**	**0.187**
4-NITROANILINE	100-01-6	24	EPA RSL	21.9	Region 5 Wildlife	21.9	7.3	0.82	0.615	0.134
4-NITROPHENOL	100-02-7	NC	None	5.12	Region 5 Wildlife	5.12	1.7	0.82	0.615	0.309
ACENAPHTHENE*	83-32-9	340	EPA RSL	20	ORNL Plant	20	6.7	0.02	0.01	0.0015
ACENAPHTHYLENE*[5]	208-96-8	340	EPA RSL	29	EPA SSL Invert	29	9.7	0.02	0.01	0.0012
ANTHRACENE*	120-12-7	1700	EPA RSL	6.8	LANL Plant	6.8	2.3	0.02	0.01	0.0012
ATRAZINE	1912-24-9	2.1	EPA RSL	NC	None	2.1	0.7	0.33	0.248	0.091
BENZALDEHYDE	100-52-7	780	EPA RSL	NC	None	780	260	0.33	0.248	0.12
BENZO (A) ANTHRACENE*	56-55-3	0.15	EPA RSL	1.1	EPA SSL Wildlife	0.15	0.05	0.02	0.01	0.0019
BENZO (A) PYRENE*	**50-32-8**	**0.015**	**EPA RSL**	**1.1**	**EPA SSL Wildlife**	**0.015**	**0.005**	**0.02**	**0.01**	**0.0033**
BENZO (B) FLUOROANTHENE*	205-99-2	0.15	EPA RSL	1.1	EPA SSL Wildlife	0.15	0.05	0.02	0.01	0.0024
BENZO (G,H,I) PERYLENE*[6]	191-24-2	170	EPA RSL	1.1	EPA SSL Wildlife	1.1	0.37	0.02	0.01	0.002
BENZO (K) FLUOROANTHENE*	207-08-9	1.5	EPA RSL	1.1	EPA SSL Wildlife	1.1	0.37	0.02	0.01	0.0031
BIS(2-CHLOROETHOXY) METHANE	**111-91-1**	**18**	**EPA RSL**	**0.302**	**Region 5 Wildlife**	**0.302**	**0.1**	**0.33**	**0.248**	**0.096**

Chemical	Chemical Abstract Service(CAS) No.	Human Health (HH) PSL (mg/kg)	HH PSL Reference	Ecological PSL (mg/kg)	Ecological PSL Reference	Minimum PSL (mg/kg)	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
BIS-(2-CHLOROETHYL) ETHER	**111-44-4**	**0.21**	**EPA RSL**	**23.7**	**Region 5 Wildlife**	**0.21**	**0.07**	**0.33**	**0.248**	**0.081**
BIS(2-ETHYLHEXYL) PHTHALATE	117-81-7	35	EPA RSL	0.925	Region 5 Wildlife	0.925	0.3	0.33	0.248	0.098
BUTYLBENZYLPHTHALATE	**85-68-7**	**260**	**EPA RSL**	**0.239**	**Region 5 Wildlife**	**0.239**	**0.08**	**0.33**	**0.248**	**0.093**
CAPROLACTAM	105-60-2	3100	EPA RSL	NC	None	3100	1030	0.33	0.248	0.144
CARBAZOLE	86-74-8	NC	None	NC	None	NC	NC	0.33	0.248	0.111
CHRYSENE*	218-01-9	15	EPA RSL	1.1	EPA SSL Wildlife	1.1	0.37	0.02	0.01	0.0017
DIBENZO (A,H)ANTHRACENE*	**53-70-3**	**0.015**	**EPA RSL**	**0.1**	**CCME Plant/Inver**	**0.015**	**0.005**	**0.02**	**0.01**	**0.0018**
DIBENZOFURAN	132-64-9	7.8	EPA RSL	6.1	LANL Plant	6.1	2	0.33	0.248	0.079
DIETHYLPHTHALATE	84-66-2	4900	EPA RSL	24.8	Region 5 Wildlife	24.8	8.3	0.33	0.248	0.08
DIMETHYLPHTHALATE	131-11-3	NC	None	200	ORNL Plant	200	66.7	0.33	0.248	0.078
DI-N-BUTYLPHTHALATE	**84-74-2**	**610**	**EPA RSL**	**0.15**	**Region 5 Wildlife**	**0.15**	**0.05**	**0.33**	**0.248**	**0.101**
DI-N-OCTYLPHTHALATE	117-84-0	NC	None	709	Region 5 Wildlife	709	236	0.33	0.248	0.211
FLUORANTHENE*	206-44-0	230	EPA RSL	29	EPA SSL Invert	29	9.7	0.02	0.01	0.0018
FLUORENE*	86-73-7	230	EPA RSL	29	EPA SSL Invert	29	9.7	0.02	0.01	0.0032
HEXACHLOROBENZENE	**118-74-1**	**0.3**	**EPA RSL**	**0.199**	**Region 5 Wildlife**	**0.199**	**0.06**	**0.33**	**0.248**	**0.082**
HEXACHLOROBUTADIENE	**87-68-3**	**6.1**	**EPA RSL**	**0.0398**	**Region 5 Wildlife**	**0.0398**	**0.013**	**0.33**	**0.248**	**0.083**
HEXACHLOROCYCLOPENTADIENE	77-47-4	37	EPA RSL	0.755	Region 5 Wildlife	0.755	0.25	0.33	0.248	0.082
HEXACHLOROETHANE	67-72-1	4.3	EPA RSL	0.596	Region 5 Wildlife	0.596	0.2	0.33	0.248	0.096
INDENO (1,2,3-CD)-PYRENE*	193-39-5	0.15	EPA RSL	0.1	CCME Plant/Inver	0.1	0.033	0.02	0.01	0.0019
ISOPHORONE	78-59-1	510	EPA RSL	139	Region 5 Wildlife	139	46.3	0.33	0.248	0.075
NAPHTHALENE*	91-20-3	3.6	EPA RSL	1	LANL Plant	1	0.33	0.02	0.01	0.0026
NITROBENZENE	98-95-3	4.8	EPA RSL	1.31	Region 5 Wildlife	1.31	0.44	0.33	0.248	0.091
N-NITROSO DIPHENYLAMINE	86-30-6	99	EPA RSL	0.545	Region 5 Wildlife	0.545	0.18	0.33	0.248	0.219
N-NITROSO-DI-N PROPYLAMINE	**621-64-7**	**0.069**	**EPA RSL**	**0.544**	**Region 5 Wildlife**	**0.069**	**0.023**	**0.33**	**0.248**	**0.083**
PENTACHLOROPHENOL	87-86-5	0.89	EPA RSL	2.1	EPA SSL Wildlife	0.89	0.3	0.82	0.615	0.237
PHENANTHRENE*[6]	85-01-8	170	EPA RSL	29	EPA SSL Invert	29	9.7	0.02	0.01	0.0018
PHENOL	108-95-2	1800	EPA RSL	30	ORNL Invert	30	10	0.33	0.248	0.156
PYRENE*	129-00-0	170	EPA RSL	1.1	EPA SSL Wildlife	1.1	0.37	0.02	0.01	0.0021
EXPLOSIVES										
1,3,5-TRINITROBENZENE	99-35-4	220	EPA RSL	0.376	Region 5 Wildlife	0.376	0.12	0.1	0.05	0.0067
1,3-DINITROBENZENE	99-65-0	0.61	EPA RSL	0.655	Region 5 Wildlife	0.61	0.2	0.1	0.05	0.0062
2,4-DINITROTOLUENE	121-14-2	1.6	EPA RSL	1.28	Region 5 Wildlife	1.28	0.43	0.1	0.05	0.015
2,6-DINITROTOLUENE	**606-20-2**	**6.1**	**EPA RSL**	**0.0328**	**Region 5 Wildlife**	**0.0328**	**0.011**	**0.1**	**0.05**	**0.027**
NITROBENZENE	98-95-3	4.8	EPA RSL	1.31	Region 5 Wildlife	1.31	0.44	0.1	0.05	0.022
2,4,6-TRINITROTOLUENE	118-96-7	3.6	EPA RSL	6	SuNonehara Plant	3.6	1.2	0.1	0.05	0.0067
2-AMINO-4,6-DINITROTOLUENE	35572-78-2	15	EPA RSL	80	LANL Plant	15	5	0.1	0.05	0.021
2-NITROTOLUENE	88-72-2	2.9	EPA RSL	NC	None	2.9	1	0.1	0.05	0.012
3-NITROTOLUENE	99-08-1	0.61	EPA RSL	NC	None	0.61	0.2	0.1	0.05	0.0079
3,5-DINITROANILINE	618-87-1	NC	None	NC	None	NC	NC	0.1	0.05	0.0035
4-AMINO-2,6-DINITROTOLUENE	19406-51-0	15	EPA RSL	80	LANL Plant	15	5	0.1	0.05	0.017
4-NITROTOLUENE	99-99-0	24	EPA RSL	NA	None	24	8	0.1	0.05	0.027

Chemical	Chemical Abstract Service(CAS) No.	Human Health (HH) PSL (mg/kg)	HH PSL Reference	Ecological PSL (mg/kg)	Ecological PSL Reference	Minimum PSL (mg/kg)	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
HMX	2691-41-0	380	EPA RSL	600	SuNonehara Invert	380	127	0.1	0.05	0.0086
TETRYL	479-45-8	24	EPA RSL	25	LANL Plant	24	8	0.1	0.05	0.0054
RDX	121-82-4	5.6	EPA RSL	98	SuNonehara Invert	5.6	1.9	0.1	0.05	0.0068
PETN	78-11-5	12	EPA RSL	NA	None	12	4	0.8	0.4	0.108
NITROGLYCERIN	**55-63-0**	**0.61**	**EPA RSL**	**NA**	**None**	**0.61**	**0.2**	**0.8**	**0.4**	**0.124**
Petroleum Hydrocarbon Fraction (EPH/VPH)										
C5-C8 alphatics (VPH)	--	1400	MEDEP-L	NC	None	1400	470	25	19	12.5
C9-C12 Aliphatics(VPH)	--	2,600	MEDEP	NC	None	2,600	870	25	19	12.5
C9-C18 Aliphatics (EPH)	--	2,600	MEDEP	NC	None	2,600	870	20	15	10
C19-C36 Aliphatics (EPH)	--	10,000[7]	MEDEP	NC	None	10,000[7]	3300	20	15	10
C9-C10 Aromatics(VPH)	--	75	MEDEP-L	NC	None	75	25	25	19	12.5
C11-C22 Aromatics (EPH)	--	460	MEDEP-L	NC	None	460	150	20	15	10

Bolded rows indicate that the PSL is between the laboratory LOQ and LOD. The Partnering Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the RI.

Shaded and Bolded rows indicate the PSL is less than the LOD. In cases where the LOD is greater than the PSL and the contaminant was not detected, the contaminant would not be retained as a COPC. However, the uncertainty associated with this decision would be discussed in the risk assessment. Moreover, a discussion regarding the likelihood of the presence of that contaminant (e.g. historic use) would be included in the risk assessment.

* indicates that these compounds will be reported from a Selective Ion Monitoring (SIM) analysis.

NC = No Criteria

Note: At the time of data evaluation, the most recent screening criteria will be utilized for the HHRA and ERA.

HH PSL References

The HH PSL reference is EPA RSL: USEPA Regions 3, 6, and 9 Regional Screening Level for Soil, Residential (USEPA, May 2012).
EPA RSLs for noncarcinogenic compounds in residential soil are adjusted by dividing by 10, equivalent to a target hazard quotient of 0.1. The EPA RSLs for carcinogenic compounds in residential soil are not adjusted and are equivalent to an incremental lifetime cancer risk (ILCR) of 1E-6.

MEDEP reference is the MEDEP Table 4 - Tier 1 Direct Contact Soil Remediation Guidelines for Smaller Petroleum Contamination Sites13 (MEDEP, 2009)

MEDEP-L reference is the MEDEP Table 3 - Tier 1 Soil Remediation Guideline Based on Petroleum Leaching to Ground Water (MEDEP, 2009).

Ecological PSL References

The selected ecological SSLs are the lowest of the selected benchmarks for plants, invertebrates, and wildlife.
The benchmarks were selected by order of preference according to the following hierarchy:

Screening Level Order of Preference for plants and invertebrates:

1. USEPA Eco SSL - EPA Ecological Soil Screening Levels (EPA SSL Plant or Invert)
2a. ORNL Benchmark (Efroymson, 1997a) - Oak Ridge National Laboratory Plant Toxicological Benchmark (ORNL Plant)
2b. ORNL Benchmark (Efroymson, 1997b) - Oak Ridge National Laboratory Invertebrate Toxicological Benchmark (ORNL Invert)
3. CCME - Canadian Council and Ministers of Environment (CCME Plant/Invert)
4. Sunahara (Sunahara et al, 2009)
5 Los Alamos National Lab Ecorisk Database (Release 2.4) LANL (2009)
6. Target Value - Ministry of Housing, Spatial Planning and Environment

Chemical	Chemical Abstract Service(CAS) No.	Human Health (HH) PSL (mg/kg)	HH PSL Reference	Ecological PSL (mg/kg)	Ecological PSL Reference	Minimum PSL (mg/kg)	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)

Screening Level Order of Preference for wildlife:

1. USEPA Eco SSL - EPA Ecological Soil Screening Levels (EPA SSL Wildlife)
2 CCME - Canadian Council and Ministers of Environment (CCME Wildlife) (presented only if no EPA SSL is available)
3. USEPA Region 5 ESL - EPA Region 5 Ecological Screening Levels (Region 5 ESL)

Footnotes

1) The value for hexavalent chromium is presented.
2) The value presented is for Vanadium and compounds.
3) The value for 1,3-dichloropropene is presented.
4) The value for 4-nitroaniline is presented.
5) The value for acenaphthene is presented.
6) The value for pyrene is presented.
7) Value is greater than ceiling value of 10,000 mg/kg. The ceiling value is used as the guideline for this compound or fraction.

SAP Worksheet #15b -- Reference Limits and Evaluation Table - Groundwater

Project screening-level support documentation is provided in Appendix B.

(UFP-QAPP Manual Section 2.8.1)

Chemical	Chemical Abstract Service (CAS) No.	Human Health (HH) Project Action Limit (PSL) (µg/L)	PSL Reference	Project Quantitation Limit Goal (PQLG) (µg/L)	Katahdin Limit of Quantitation (µg/L)	Katahdin Limit of Detection (µg/L)	Katahdin Detection Limit (µg/L)
TARGET ANALYTE LIST METALS							
ALUMINUM	7429-90-5	1600	Tapwater RSL	530	300	40	4.4
ANTIMONY	**7440-36-0**	**0.6**	**Tapwater RSL**	**0.2**	**1**	**0.5**	**0.054**
ARSENIC	**7440-38-2**	**0.045**	**Tapwater RSL**	**0.015**	**5**	**4**	**2.2**
BARIUM	7440-39-3	290	Tapwater RSL	96.7	2	1	0.27
BERYLLIUM	7440-41-7	1.6	Tapwater RSL	0.53	1	0.2	0.034
CADMIUM	**7440-43-9**	**0.69**	**Tapwater RSL**	**0.23**	**1**	**0.2**	**0.03**
CALCIUM	7440-70-2	NC	None	NC	100	80	20
CHROMIUM[1]	**7440-47-3**	**0.031**	**Tapwater RSL**	**0.01**	**4**	**3**	**0.22**
COBALT	**7440-48-4**	**0.47**	**Tapwater RSL**	**0.16**	**1**	**0.3**	**0.06**
COPPER	7440-50-8	62	Tapwater RSL	20.7	3	2	0.18
IRON	7439-89-6	1100	Tapwater RSL	367	100	60	13
LEAD	7439-92-1	15	MCL	5	1	0.5	0.074
MERCURY	**7439-97-6**	**0.063**	**Tapwater RSL**	**0.021**	**0.2**	**0.1**	**0.013**
MAGNESIUM	7439-95-4	NC	None	NC	100	80	7.8
MANGANESE	7439-96-5	32	Tapwater RSL	10.7	2	1	0.35
NICKEL	7440-02-0	30	Tapwater RSL	10	2	1.2	0.15
POTASSIUM	7440-09-7	NC	None	NC	1000	400	31
SELENIUM	7782-49-2	7.8	Tapwater RSL	2.6	5	3	0.19
SILVER	7440-22-4	7.1	Tapwater RSL	2.4	1	0.4	0.05
SODIUM	7440-23-5	NC	None	NC	1000	400	18
THALLIUM	**7440-28-0**	**0.016**	**Tapwater RSL**	**0.005**	**1**	**0.4**	**0.06**
VANADIUM[2]	7440-62-2	7.8	Tapwater RSL	2.6	5	4	0.51
ZINC	7440-66-6	470	Tapwater RSL	157	10	8	3.9
TARGET COMPOUND LIST VOLATILE ORGANIC COMPOUNDS							
1,1- DICHLOROETHANE	75-34-3	2.4	Tapwater RSL	0.8	1	0.5	0.21
1,1,1-TRICHLOROETHANE	71-55-6	750	Tapwater RSL	250	1	0.5	0.2
1,1,2- TRICHLOROETHANE	79-00-5	6.3	Tapwater RSL	2.1	1	0.5	0.33
1,1,2,2- TETRACHLORETHANE	**79-34-5**	**0.066**	**Tapwater RSL**	**0.022**	**1**	**0.5**	**0.38**
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	76-13-1	5300	Tapwater RSL	1770	1	0.5	0.31
1,1-DICHLOROETHENE	75-35-4	26	Tapwater RSL	8.7	1	0.5	0.35
1,2- DICHLOROBENZENE	95-50-1	28	Tapwater RSL	9.3	1	0.5	0.15
1,2- DICHLOROETHANE	**107-06-2**	**0.15**	**Tapwater RSL**	**0.05**	**1**	**0.5**	**0.2**
1,2,3-TRICHLOROBENZENE	**87-61-6**	**0.52**	**Tapwater RSL**	**0.17**	**1**	**0.5**	**0.27**
1,2,4-TRICHLOROBENZENE	120-82-1	7	Tapwater RSL	2.3	1	0.5	0.37
1,2-DIBROMO-3-CHLOROPROPANE (by 504)	**96-12-8**	**0.00032**	**Tapwater RSL**	**0.00011**	**0.05**	**0.025**	**0.0063**
1,2-DIBROMOETHANE (by 504)	**106-93-4**	**0.0065**	**Tapwater RSL**	**0.0022**	**0.05**	**0.025**	**0.0073**
1,2-DICHLOROPROPANE	**78-87-5**	**0.38**	**Tapwater RSL**	**0.13**	**1**	**0.5**	**0.25**

Chemical	Chemical Abstract Service (CAS) No.	Human Health (HH) Project Action Limit (PSL) (µg/L)	PSL Reference	Project Quantitation Limit Goal (PQLG) (µg/L)	Katahdin Limit of Quantitation (µg/L)	Katahdin Limit of Detection (µg/L)	Katahdin Detection Limit (µg/L)
1,3-DICHLOROBENZENE	541-73-1	NC	None	NC	1	0.5	0.26
1,4- DICHLOROBENZENE	**106-46-7**	**0.42**	**Tapwater RSL**	**0.14**	**1**	**0.5**	**0.24**
2-BUTANONE	78-93-3	490	Tapwater RSL	163	5	2.5	1.31
2-HEXANONE	**591-78-6**	**3.4**	**Tapwater RSL**	**1.1**	**5**	**2.5**	**1.7**
4-METHYL-2-PENTANONE	108-10-1	100	Tapwater RSL	33	5	2.5	1.32
ACETONE	67-64-1	1200	Tapwater RSL	400	5	2.5	2.21
BENZENE	**71-43-2**	**0.39**	**Tapwater RSL**	**0.13**	**1**	**0.5**	**0.26**
BROMOCHLOROMETHANE	74-97-5	8.3	Tapwater RSL	2.8	1	0.5	0.33
BROMODICHLOROMETHANE	**75-27-4**	**0.12**	**Tapwater RSL**	**0.04**	**1**	**0.5**	**0.21**
BROMOFORM	75-25-2	7.9	Tapwater RSL	2.6	1	0.5	0.23
BROMOMETHANE	**74-83-9**	**0.7**	**Tapwater RSL**	**0.23**	**2**	**1**	**0.49**
CARBON DISULFIDE	75-15-0	72	Tapwater RSL	24	1	0.5	0.25
CARBON TETRACHLORIDE	**56-23-5**	**0.39**	**Tapwater RSL**	**0.13**	**1**	**0.5**	**0.22**
CHLOROBENZENE	108-90-7	7.2	Tapwater RSL	2.4	1	0.5	0.22
CHLOROETHANE	75-00-3	2100	Tapwater RSL	700	2	1	0.55
CHLOROFORM	**67-66-3**	**0.19**	**Tapwater RSL**	**0.063**	**1**	**0.5**	**0.32**
CHLOROMETHANE	74-87-3	19	Tapwater RSL	6.3	2	1	0.36
CIS-1,2- DICHLOROETHENE	156-59-2	2.8	Tapwater RSL	0.93	1	0.5	0.21
CIS-1,3- DICHLOROPROPENE[3]	**10061-01-5**	**0.41**	**Tapwater RSL**	**0.14**	**1**	**0.5**	**0.19**
CYCLOHEXANE	110-82-7	1300	Tapwater RSL	430	1	0.5	0.31
DIBROMOCHLOROMETHANE	**124-48-1**	**0.15**	**Tapwater RSL**	**0.05**	**1**	**0.5**	**0.3**
DICHLORODIFLUOROMETHANE	75-71-8	19	Tapwater RSL	6.3	2	1	0.24
ETHYLBENZENE	100-41-4	1.3	Tapwater RSL	0.43	1	0.5	0.21
ISOPROPYLBENZENE	98-82-8	39	Tapwater RSL	13	1	0.5	0.23
METHYL ACETATE	79-20-9	1600	Tapwater RSL	530	1	0.75	0.53
METHYL TERT-BUTYL ETHER	1634-04-4	12	Tapwater RSL	4	1	0.5	0.36
METHYLCYCLOHEXANE	108-87-2	NC	None	NC	1	0.5	0.3
METHYLENE CHLORIDE	75-09-2	8.4	Tapwater RSL	2.8	5	2.5	1.13
STYRENE	100-42-5	110	Tapwater RSL	36.7	1	0.5	0.23
TETRACHLOROETHENE	127-18-4	3.5	Tapwater RSL	1.2	1	0.5	0.4
TOLUENE	108-88-3	86	Tapwater RSL	28.7	1	0.5	0.27
O-XYLENE	95-47-6	19	Tapwater RSL	6.3	1	0.5	0.25
m,p-XYLENE	108-38-3	19	Tapwater RSL	6.3	1	0.5	0.59
TOTAL XYLENES	1330-20-7	19	Tapwater RSL	6.3	3	1.5	0.25
TRANS-1,2- DICHLOROETHENE	156-60-5	8.6	Tapwater RSL	2.9	1	0.5	0.25
TRANS-1,3-DICHLOROPROPENE[3]	**10061-02-6**	**0.41**	**Tapwater RSL**	**0.14**	**1**	**0.5**	**0.2**
TRICHLOROETHENE	**79-01-6**	**0.26**	**Tapwater RSL**	**0.087**	**1**	**0.5**	**0.28**
TRICHLOROFLUOROMETHANE	75-69-4	110	Tapwater RSL	36.7	1	0.5	0.24
VINYL CHLORIDE	**75-01-4**	**0.015**	**Tapwater RSL**	**0.005**	**2**	**1**	**0.25**

Chemical	Chemical Abstract Service (CAS) No.	Human Health (HH) Project Action Limit (PSL) (µg/L)	PSL Reference	Project Quantitation Limit Goal (PQLG) (µg/L)	Katahdin Limit of Quantitation (µg/L)	Katahdin Limit of Detection (µg/L)	Katahdin Detection Limit (µg/L)
TARGET COMPOUND LIST SEMI-VOLATILE ORGANIC COMPOUNDS							
1,1'-BIPHENYL	**92-52-4**	**0.083**	**Tapwater RSL**	**0.028**	**10**	**7.5**	**2.7**
1,4-DIOXANE*	**123-91-1**	**0.67**	**Tapwater RSL**	**0.22**	**1**	**0.5**	**0.029**
1,2,4,5-TETRACHLOROBENZENE	**95-94-3**	**0.12**	**Tapwater RSL**	**0.04**	**10**	**7.5**	**1.8**
2,2-OXYBIS(1-CHLOROPROPANE)	**108-60-1**	**0.31**	**Tapwater RSL**	**0.1**	**10**	**7.5**	**2.1**
2,3,4,6-TETRACHLOROPHENOL	58-90-2	17	Tapwater RSL	5.7	10	7.5	2.7
2,4,5-TRICHLOROPHENOL	95-95-4	89	Tapwater RSL	29.7	25	18.8	3.6
2,4,6-TRICHLOROPHENOL	**88-06-2**	**0.9**	**Tapwater RSL**	**0.3**	**10**	**7.5**	**2.7**
2,4-DICHLOROPHENOL	**120-83-2**	**3.5**	**Tapwater RSL**	**1.2**	**10**	**7.5**	**3**
2,4-DIMETHYLPHENOL	105-67-9	27	Tapwater RSL	9	10	7.5	4.4
2,4-DINITROPHENOL	**51-28-5**	**3**	**Tapwater RSL**	**1**	**25**	**18.8**	**1**
2,4-DINITROTOLUENE	**121-14-2**	**0.2**	**Tapwater RSL**	**0.067**	**10**	**7.5**	**2.2**
2,6-DINITROTOLUENE	**606-20-2**	**1.5**	**Tapwater RSL**	**0.5**	**10**	**7.5**	**2**
2-CHLORONAPHTHALENE	91-58-7	55	Tapwater RSL	18.3	10	7.5	2.9
2-CHLOROPHENOL	**95-57-8**	**7.1**	**Tapwater RSL**	**2.4**	**10**	**7.5**	**3.2**
2-METHYLNAPHTHALENE*	91-57-6	2.7	Tapwater RSL	0.9	0.2	0.1	0.077
2-METHYLPHENOL	95-48-7	72	Tapwater RSL	24	10	7.5	3.8
2-NITROANILINE	**88-74-4**	**15**	**Tapwater RSL**	**5**	**25**	**18.8**	**1.8**
2-NITROPHENOL	88-75-5	NC	None	NC	10	7.5	2.7
3,3'-DICHLOROBENZIDINE	**91-94-1**	**0.11**	**Tapwater RSL**	**0.04**	**10**	**7.5**	**1.1**
3-NITROANILINE[4]	**99-09-2**	**3.3**	**Tapwater RSL**	**1.1**	**25**	**18.8**	**1.5**
4,6-DINITRO-2-METHYLPHENOL	**534-52-1**	**0.12**	**Tapwater RSL**	**0.04**	**25**	**18.8**	**2**
4-BROMOPHENYL-PHENYLETHER	101-55-3	NC	None	NC	10	7.5	1.9
4-CHLORO-3-METHYLPHENOL	59-50-7	110	Tapwater RSL	36.7	10	7.5	3.6
4-CHLOROANILINE	**106-47-8**	**0.32**	**Tapwater RSL**	**0.32**	**10**	**7.5**	**1.9**
4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	NC	None	NC	10	7.5	2.2
4-METHYLPHENOL	106-44-5	140	Tapwater RSL	46.7	10	7.5	5.6
4-NITROANILINE	**100-01-6**	**3.3**	**Tapwater RSL**	**1.1**	**25**	**18.8**	**1.6**
4-NITROPHENOL	100-02-7	NC	None	NC	25	18.8	1.8
ACENAPHTHENE*	83-32-9	40	Tapwater RSL	13.3	0.2	0.1	0.064
ACENAPHTHYLENE*[5]	208-96-8	40	Tapwater RSL	13.3	0.2	0.1	0.054
ANTHRACENE*	120-12-7	130	Tapwater RSL	43.3	0.2	0.1	0.044
ATRAZINE	**1912-24-9**	**0.26**	**Tapwater RSL**	**0.087**	**10**	**7.5**	**3.3**
BENZALDEHYDE	100-52-7	150	Tapwater RSL	50	10	7.5	1
BENZO (A) ANTHRACENE*	**56-55-3**	**0.029**	**Tapwater RSL**	**0.01**	**0.2**	**0.1**	**0.046**
BENZO (A) PYRENE*	**50-32-8**	**0.0029**	**Tapwater RSL**	**0.001**	**0.2**	**0.1**	**0.066**
BENZO (B) FLUOROANTHENE*	**205-99-2**	**0.029**	**Tapwater RSL**	**0.01**	**0.2**	**0.1**	**0.089**
BENZO (G,H,I) PERYLENE*[6]	191-24-2	8.7	Tapwater RSL	2.9	0.2	0.1	0.065
BENZO (K) FLUOROANTHENE*	207-08-9	0.29	Tapwater RSL	0.1	0.2	0.1	0.049
BIS(2-CHLOROETHOXY) METHANE	**111-91-1**	**4.7**	**Tapwater RSL**	**1.6**	**10**	**7.5**	**2.1**
BIS-(2-CHLOROETHYL) ETHER	**111-44-4**	**0.012**	**Tapwater RSL**	**0.004**	**10**	**7.5**	**2**

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BIS(2-ETHYLHEXYL) PHTHALATE	**117-81-7**	**0.071**	**Tapwater RSL**	**0.024**	**10**	**7.5**	**1.8**
BUTYLBENZYLPHTHALATE	85-68-7	14	Tapwater RSL	4.7	10	7.5	1.9
CAPROLACTAM	105-60-2	770	Tapwater RSL	260	10	7.5	0.4
CARBAZOLE	86-74-8	NC	None	NC	10	7.5	2.1
CHRYSENE*	218-01-9	2.9	Tapwater RSL	1	0.2	0.1	0.036
DIBENZO (A,H)-ANTHRACENE*	**53-70-3**	**0.0029**	**Tapwater RSL**	**0.001**	**0.2**	**0.1**	**0.07**
DIBENZOFURAN	**132-64-9**	**0.58**	**Tapwater RSL**	**0.19**	**10**	**7.5**	**1.6**
DIETHYLPHTHALATE	84-66-2	1100	Tapwater RSL	370	10	7.5	2
DIMETHYLPHTHALATE	131-11-3	NC	None	NC	10	7.5	2.01
DI-N-BUTYLPHTHALATE	84-74-2	67	Tapwater RSL	22.3	10	7.5	2.5
DI-N-OCTYLPHTHALATE	117-84-0	NC	None	NC	10	7.5	1.8
FLUORANTHENE*	206-44-0	63	Tapwater RSL	21	0.2	0.1	0.073
FLUORENE*	86-73-7	22	Tapwater RSL	7.3	0.2	0.1	0.061
HEXACHLOROBENZENE	**118-74-1**	**0.042**	**Tapwater RSL**	**0.014**	**10**	**7.5**	**2.1**
HEXACHLOROBUTADIENE	**87-68-3**	**0.26**	**Tapwater RSL**	**0.087**	**10**	**7.5**	**1.8**
HEXACHLOROCYCLOPENTADIENE	**77-47-4**	**2.2**	**Tapwater RSL**	**0.73**	**10**	**7.5**	**1.2**
HEXACHLOROETHANE	**67-72-1**	**0.51**	**Tapwater RSL**	**0.17**	**10**	**7.5**	**2.3**
INDENO (1,2,3-CD)-PYRENE*	**193-39-5**	**0.029**	**Tapwater RSL**	**0.001**	**0.2**	**0.1**	**0.052**
ISOPHORONE	78-59-1	67	Tapwater RSL	22.3	10	7.5	1.7
NAPHTHALENE*	**91-20-3**	**0.14**	**Tapwater RSL**	**0.047**	**0.2**	**0.1**	**0.064**
NITROBENZENE	**98-95-3**	**0.12**	**Tapwater RSL**	**0.04**	**10**	**7.5**	**3.1**
N-NITROSO DIPHENYLAMINE	86-30-6	10	Tapwater RSL	3.3	10	7.5	3.7
N-NITROSO-DI-N PROPYLAMINE	**621-64-7**	**0.0093**	**Tapwater RSL**	**0.0031**	**10**	**7.5**	**1.9**
PENTACHLOROPHENOL	**87-86-5**	**0.17**	**Tapwater RSL**	**0.057**	**25**	**18.8**	**2.3**
PHENANTHRENE*[6]	85-01-8	8.7	Tapwater RSL	2.9	0.2	0.1	0.051
PHENOL	108-95-2	450	Tapwater RSL	150	10	7.5	1.8
PYRENE*	129-00-0	8.7	Tapwater RSL	2.9	0.2	0.1	0.059
EXPLOSIVES							
1,3,5-Trinitrobenzene	99-35-4	46	Tapwater RSL	15.3	0.25	0.125	0.04
1,3-Dinitrobenzene	**99-65-0**	**0.15**	**Tapwater RSL**	**0.05**	**0.25**	**0.125**	**0.045**
2,4-Dinitrotoluene	**121-14-2**	**0.2**	**Tapwater RSL**	**0.067**	**0.25**	**0.125**	**0.052**
2,6-Dinitrotoluene	606-20-2	1.5	Tapwater RSL	0.5	0.25	0.125	0.056
Nitrobenzene	**98-95-3**	**0.12**	**Tapwater RSL**	**0.04**	**0.25**	**0.125**	**0.071**
2,4,6-Trinitrotoluene	118-96-7	0.76	Tapwater RSL	0.25	0.25	0.125	0.064
2-Amino-4,6-Dinitrotoluene	35572-78-2	3	Tapwater RSL	1	0.25	0.125	0.038
2-Nitrotoluene	88-72-2	0.27	Tapwater RSL	0.09	0.25	0.125	0.071
3-Nitrotoluene	**99-08-1**	**0.13**	**Tapwater RSL**	**0.043**	**0.25**	**0.125**	**0.063**
3,5-Dinitroaniline	618-87-1	NC	None	NC	0.25	0.125	0.07
4-Amino-2,6-Dinitrotoluene	19406-51-0	3	Tapwater RSL	1	0.25	0.125	0.053
4-Nitrotoluene	99-99-0	3.7	Tapwater RSL	1.2	0.25	0.125	0.06
HMX	2691-41-0	78	Tapwater RSL	26	0.25	0.125	0.043
Tetryl	479-45-8	6.3	Tapwater RSL	2.1	0.25	0.125	0.06

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RDX	121-82-4	0.61	Tapwater RSL	0.2	0.25	0.125	0.046
PETN	**78-11-5**	**3**	**Tapwater RSL**	**1**	**4**	**2**	**0.58**
Nitroglycerin	**55-63-0**	**0.15**	**Tapwater RSL**	**0.05**	**4**	**2**	**0.67**
MISCELLANEOUS							
Perchlorate[7]	14797-73-0	1.1	Tapwater RSL	0.37	0.2	0.04	0.015
Petroleum Hydrocarbon Fraction							
C5-C8 alphatics	--	200	MEDEP	66.7	100	75	50
C9-C12 Aliphatics	--	500	MEDEP	170	100	75	50
C9-C18 Aliphatics	--	500	MEDEP	170	100	75	50
C19-C36 Aliphatics	--	8,000	MEDEP	2700	100	75	50
C9-C10 Aromatics	--	200	MEDEP	66.7	100	75	50
C11-C22 Aromatics	--	200	MEDEP	66.7	100	75	50

Bolded rows indicate that the PSL is between the laboratory LOQ and LOD. The Partnering Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the RI.

Shaded and Bolded rows indicate the PSL is less than the LOD; therefore, the Partnering Team In cases where the LOD is greater than the PSL and the contaminant was not detected, the contaminant would not be retained as a COPC. However, the uncertainty associated with this decision would be discussed in the risk assessment. Moreover, a discussion regarding the likelihood of the presence of that contaminant (e.g. historic use) would be included in the risk assessment.

* indicates that these compounds will be reported from a Selective Ion Monitoring (SIM) analysis.

MCL = Maximum Contaminant Level
NC = No Criteria

Note: At the time of data evaluation, the most recent screening criteria will be utilized for the HHRA and ERA.

HH PSL References

The HH PSL reference is EPA Tapwater RSL: USEPA Regions 3, 6, and 9 Regional Screening Level for Tapwater (USEPA, May 2012); Tapwater RSLs for noncarcinogenic compounds in groundwater are adjusted by dividing by 10, equivalent to a target hazard quotient of 0.1. The tapwater RSLs for carcinogenic compounds in groundwater are not adjusted and are equivalent to an incremental lifetime cancer risk (ILCR) of 1E-6. MEDEP reference is the MEDEP Table 2 - Action Level Concentrations in Drinking Water Supply Wells for Temporary Treatment (MEDEP, 2009).

Footnotes

1) The value for hexavalent chromium is presented.
2) The value presented is for Vanadium and compounds.
3) The value for 1,3-dichloropropene is presented.
4) The value for 4-nitroaniline is presented.
5) The value for acenaphthene is presented.
6) The value for pyrene is presented.
7) Perchlorate will be analyzed by TestAmerica.

SAP Worksheet #15c -- Reference Limits and Evaluation Table - Sediment

Project screening-level support documentation is provided in Appendix B.

(UFP-QAPP Manual Section 2.8.1)

Chemical	Chemical Abstract Service (CAS) No.	Ecological Project Action Limit (PSL) (mg/kg)	PSL Reference	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
TARGET ANALYTE LIST METALS							
ALUMINUM	7429-90-5	25500	NOAA	8500	30	4	0.51
Antimony	7440-36-0	3	NOAA	1	0.1	0.05	0.02
Arsenic	7440-38-2	9.79	TEC	3.3	0.5	0.4	0.15
BARIUM	7440-39-3	48	NOAA	16	0.2	0.1	0.037
BERYLLIUM	7440-41-7	NC	None	NC	0.1	0.02	0.0041
CADMIUM	7440-43-9	0.99	TEC	0.33	0.1	0.02	0.007
CALCIUM	7440-70-2	NC	None	NC	10	8	3.83
CHROMIUM	7440-47-3	43.4	TEC	14.5	0.4	0.3	0.05
COBALT	7440-48-4	50	LEL	16.7	0.1	0.03	0.0054
Copper	7440-50-8	31.6	TEC	10.5	0.3	0.2	0.071
IRON	7439-89-6	20000	LEL	6700	10	6	2.4
Lead	7439-92-1	35.8	TEC	11.9	0.1	0.05	0.007
MERCURY	7439-97-6	0.18	TEC	0.06	0.033	0.017	0.0052
MAGNESIUM	7439-95-4	NC	None	NC	10	8	1.37
MANGANESE	7439-96-5	460	LEL	153	0.2	0.1	0.042
NICKEL	7440-02-0	22.7	TEC	7.6	0.2	0.12	0.026
POTASSIUM	7440-09-7	NC	None	NC	100	40	4.6
SELENIUM	7782-49-2	1	NOAA	0.33	0.5	0.3	0.039
SILVER	7440-22-4	0.5	LEL	0.17	0.1	0.04	0.0066
SODIUM	7440-23-5	NC	None	NC	100	40	2.6
THALLIUM	7440-28-0	NC	None	NC	0.1	0.04	0.0094
VANADIUM	7440-62-2	57	NOAA	19	0.5	0.4	0.11
Zinc	7440-66-6	121	TEC	40.3	1	0.8	0.13
TARGET COMPOUND LIST VOLATILE ORGANIC COMPOUNDS							
1,1,1-TRICHLOROETHANE	71-55-6	0.17	EPA SQB	0.057	0.005	0.0025	0.00042
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	76-13-1	NC	None	NC	0.005	0.0025	0.0009
1,1,2,2- TETRACHLORETHANE	79-34-5	0.94	EPA SQB	0.31	0.005	0.0025	0.00084
1,1,2- TRICHLOROETHANE	79-00-5	1.2	SCV	0.4	0.005	0.0025	0.00097
1,1- DICHLOROETHANE	75-34-3	0.027	SCV	0.009	0.005	0.0025	0.0017
1,1-DICHLOROETHENE	75-35-4	0.031	SCV	0.01	0.005	0.0025	0.00093
1,2,3-TRICHLOROBENZENE	87-61-6	NC	None	NC	0.005	0.0025	0.00076
1,2,4-TRICHLOROBENZENE	120-82-1	9.2	EPA SQB	3.07	0.005	0.0025	0.00079
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	NC	None	NC	0.005	0.0025	0.0015
1,2-DIBROMOETHANE	106-93-4	NC	None	NC	0.005	0.0025	0.0012
1,2- DICHLOROBENZENE	95-50-1	0.34	EPA SQB	0.11	0.005	0.0025	0.00078
1,2- DICHLOROETHANE	107-06-2	0.25	SCV	0.083	0.005	0.0025	0.001
1,2-DICHLOROPROPANE	78-87-5	0.333	ESV	0.111	0.005	0.0025	0.0014

Chemical	Chemical Abstract Service (CAS) No.	Ecological Project Action Limit (PSL) (mg/kg)	PSL Reference	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
1,3-DICHLOROBENZENE	541-73-1	1.7	EPA SQB	0.57	0.005	0.0025	0.00062
1,4- DICHLOROBENZENE	106-46-7	0.35	EPA SQB	0.12	0.005	0.0025	0.00044
2-BUTANONE	78-93-3	0.27	SCV	0.09	0.025	0.0125	0.0059
2-HEXANONE	**591-78-6**	**0.022**	**SCV**	**0.007**	**0.025**	**0.0125**	**0.0048**
4-METHYL-2-PENTANONE	108-10-1	0.033	SCV	0.011	0.025	0.0125	0.0059
ACETONE	**67-64-1**	**0.0087**	**SCV**	**0.0029**	**0.025**	**0.0125**	**0.0051**
BENZENE	71-43-2	0.057	EPA SQB	0.019	0.005	0.0025	0.00092
BROMODICHLOROMETHANE	75-27-4	NC	None	NC	0.005	0.0025	0.0006
BROMOCHLOROMETHANE	74-97-5	NC	None	NC	0.005	0.0025	0.00091
BROMOFORM	75-25-2	0.65	SCV	0.22	0.005	0.0025	0.0007
BROMOMETHANE	**74-83-9**	**0.00137**	**ESV**	**0.00046**	**0.01**	**0.005**	**0.0011**
CARBON DISULFIDE	**75-15-0**	**0.00085**	**SCV**	**0.00028**	**0.005**	**0.0025**	**0.00078**
CARBON TETRACHLORIDE	56-23-5	1.2	EPA SQB	0.4	0.005	0.0025	0.0013
CHLOROBENZENE	108-90-7	0.82	EPA SQB	0.27	0.005	0.0025	0.00051
CHLOROETHANE	75-00-3	NC	None	NC	0.01	0.005	0.0013
CHLOROFORM	67-66-3	0.022	SCV	0.007	0.005	0.0025	0.00035
CHLOROMETHANE	74-87-3	NC	None	NC	0.01	0.005	0.0014
CIS-1,2- DICHLOROETHENE	156-59-2	0.4	SCV	0.13	0.005	0.0025	0.00091
CIS-1,3- DICHLOROPROPENE	**10061-01-5**	**0.000051**	**SCV**	**0.000017**	**0.005**	**0.0025**	**0.00072**
CYCLOHEXANE	110-82-7	NC	None	NC	0.005	0.0025	0.0014
DIBROMOCHLOROMETHANE	124-48-1	NC	None	NC	0.005	0.0025	0.001
DICHLORODIFLUOROMETHANE	75-71-8	NC	None	NC	0.01	0.005	0.00092
ETHYLBENZENE	100-41-4	3.6	EPA SQB	1.2	0.005	0.0025	0.00065
ISOPROPYLBENZENE	98-82-8	NC	None	NC	0.005	0.0025	0.00092
METHYL ACETATE	79-20-9	NC	None	NC	0.005	0.003	0.0027
METHYLCYCLOHEXANE	108-87-2	NC	None	NC	0.005	0.0025	0.00096
METHYLENE CHLORIDE	75-09-2	0.37	SCV	0.12	0.025	0.0125	0.0079
METHYL TERT-BUTYL ETHER	1634-04-4	NC	None	NC	0.005	0.0025	0.0011
STYRENE	100-42-5	0.254	ESV	0.085	0.005	0.0025	0.00051
TETRACHLOROETHENE	127-18-4	0.53	EPA SQB	0.18	0.005	0.0025	0.0012
TOLUENE	108-88-3	0.67	EPA SQB	0.22	0.005	0.0025	0.0014
TRANS-1,2- DICHLOROETHENE	156-60-5	0.4	SCV	0.13	0.005	0.0025	0.00071
TRANS-1,3-DICHLOROPROPENE	**10061-02-6**	**0.000051**	**SCV**	**0.000017**	**0.005**	**0.0025**	**0.00086**
TRICHLOROETHENE	79-01-6	1.6	EPA SQB	0.53	0.005	0.0025	0.00059
TRICHLOROFLUOROMETHANE	75-69-4	NC	None	NC	0.01	0.005	0.00091
VINYL CHLORIDE	75-01-4	0.202	ESV	0.067	0.01	0.005	0.00087
O-XYLENE	95-94-6	NC	None	NC	0.005	0.0025	0.0013
m,p-XYLENE	179601-23-1	NC	None	NC	0.01	0.005	0.0017
TARGET COMPOUND LIST SEMI-VOLATILE ORGANIC COMPOUNDS							
1,1'-BIPHENYL	92-52-4	1.1	EPA SQB	0.37	0.33	0.248	0.073
1,4-DIOXANE*	123-91-1	0.119	ESV	0.04	0.1	0.05	0.0011
1,2,4,5-TETRACHLOROBENZENE	95-94-3	1.252	ESV	0.42	0.33	0.248	0.135
2,2-OXYBIS(1-CHLOROPROPANE)	108-60-1	NC	None	NC	0.33	0.248	0.089

Chemical	Chemical Abstract Service (CAS) No.	Ecological Project Action Limit (PSL) (mg/kg)	PSL Reference	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
2,3,4,6-TETRACHLOROPHENOL	**58-90-2**	**0.129**	**ESV**	**0.043**	**0.33**	**0.248**	**0.14**
2,4,5-TRICHLOROPHENOL	**95-95-4**	**0.003**	**NOAA**	**0.001**	**0.82**	**0.615**	**0.155**
2,4,6-TRICHLOROPHENOL	**88-06-2**	**0.006**	**NOAA**	**0.002**	**0.33**	**0.248**	**0.155**
2,4-DICHLOROPHENOL	**120-83-2**	**0.0002083**	**NOAA**	**0.00007**	**0.33**	**0.248**	**0.15**
2,4-DIMETHYLPHENOL	**105-67-9**	**0.018**	**NOAA**	**0.006**	**0.33**	**0.248**	**0.165**
2,4-DINITROPHENOL	**51-28-5**	**0.00621**	**ESV**	**0.0021**	**0.82**	**0.615**	**0.377**
2,4-DINITROTOLUENE	**121-14-2**	**0.0144**	**ESV**	**0.0048**	**0.33**	**0.248**	**0.085**
2,6-DINITROTOLUENE	**606-20-2**	**0.0398**	**ESV**	**0.013**	**0.33**	**0.248**	**0.079**
2-CHLORONAPHTHALENE	91-58-7	0.417	ESV	0.14	0.33	0.248	0.087
2-CHLOROPHENOL	**95-57-8**	**0.000333**	**NOAA**	**0.00011**	**0.33**	**0.248**	**0.164**
2-METHYLNAPHTHALENE*	91-57-6	0.064	NOAA	0.02	0.02	0.01	0.0017
2-METHYLPHENOL	**95-48-7**	**0.008**	**NOAA**	**0.0027**	**0.33**	**0.248**	**0.2**
2-NITROANILINE	88-74-4	NC	None	NC	0.82	0.615	0.075
2-NITROPHENOL	88-75-5	NC	None	NC	0.33	0.248	0.167
3,3'-DICHLOROBENZIDINE	**91-94-1**	**0.127**	**ESV**	**0.042**	**0.33**	**0.248**	**0.114**
3-NITROANILINE	99-09-2	NC	None	NC	0.82	0.615	0.094
4,6-DINITRO-2-METHYLPHENOL	**534-52-1**	**0.104**	**ESV**	**0.035**	**0.82**	**0.615**	**0.337**
4-BROMOPHENYL-PHENYLETHER	101-55-3	1.3	EPA SQB	0.43	0.33	0.248	0.085
4-CHLORO-3-METHYLPHENOL	59-50-7	0.388	ESV	0.13	0.33	0.248	0.166
4-CHLOROANILINE	**106-47-8**	**0.146**	**ESV**	**0.05**	**0.33**	**0.248**	**0.119**
4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	NC	None	NC	0.33	0.248	0.078
4-METHYLPHENOL	**106-44-5**	**0.1**	**NOAA**	**0.03**	**0.33**	**0.248**	**0.187**
4-NITROANILINE	100-01-6	NC	None	NC	0.82	0.615	0.134
4-NITROPHENOL	**100-02-7**	**0.0133**	**ESV**	**0.004**	**0.82**	**0.615**	**0.309**
ACENAPHTHENE*	**83-32-9**	**0.016**	**EPA SQB**	**0.005**	**0.02**	**0.01**	**0.0015**
ACENAPHTHYLENE*	**208-96-8**	**0.00587**	**NOAA**	**0.002**	**0.02**	**0.01**	**0.0012**
ANTHRACENE*	120-12-7	0.0572	TEC	0.019	0.02	0.01	0.0012
ATRAZINE	1912-24-9	NC	None	NC	0.33	0.248	0.091
BENZALDEHYDE	100-52-7	NC	None	NC	0.33	0.248	0.12
BENZO (A) ANTHRACENE*	56-55-3	0.108	TEC	0.036	0.02	0.01	0.0019
BENZO (A) PYRENE*	50-32-8	0.15	TEC	0.05	0.02	0.01	0.0033
BENZO (B) FLUOROANTHENE*	205-99-2	1.8	NOAA	0.6	0.02	0.01	0.0024
BENZO (G,H,I) PERYLENE*	191-24-2	0.17	LEL	0.057	0.02	0.01	0.002
BENZO (K) FLUOROANTHENE*	207-08-9	0.24	LEL	0.08	0.02	0.01	0.0031
BIS(2-CHLOROETHOXY) METHANE	111-91-1	NC	None	NC	0.33	0.248	0.096
BIS-(2-CHLOROETHYL) ETHER	111-44-4	3.52	ESV	1.2	0.33	0.248	0.081
BIS(2-ETHYLHEXYL) PHTHALATE	117-81-7	0.75	NOAA	0.25	0.33	0.248	0.098
BUTYLBENZYLPHTHALATE	85-68-7	11	EPA SQB	3.7	0.33	0.248	0.093
CAPROLACTAM	105-60-2	NC	None	NC	0.33	0.248	0.144
CARBAZOLE	86-74-8	NC	None	NC	0.33	0.248	0.111
CHRYSENE*	218-01-9	0.166	TEC	0.055	0.02	0.01	0.0017
DIBENZO (A,H)-ANTHRACENE*	53-70-3	0.033	TEC	0.011	0.02	0.01	0.0018
DIBENZOFURAN	132-64-9	2	EPA SQB	0.67	0.33	0.248	0.079

Chemical	Chemical Abstract Service (CAS) No.	Ecological Project Action Limit (PSL) (mg/kg)	PSL Reference	Project Quantitation Limit Goal (PQLG) (mg/kg)	Katahdin Limit of Quantitation (mg/kg)	Katahdin Limit of Detection (mg/kg)	Katahdin Detection Limit (mg/kg)
DIETHYLPHTHALATE	84-66-2	0.63	EPA SQB	0.21	0.33	0.248	0.08
DIMETHYLPHTHALATE	**131-11-3**	**0.006**	**NOAA**	**0.002**	**0.33**	**0.248**	**0.078**
DI-N-BUTYLPHTHALATE	84-74-2	11	EPA SQB	3.7	0.33	0.248	0.101
DI-N-OCTYLPHTHALATE	**117-84-0**	**0.061**	**NOAA**	**0.02**	**0.33**	**0.248**	**0.211**
FLUORANTHENE*	206-44-0	0.423	TEC	0.14	0.02	0.01	0.0018
FLUORENE*	86-73-7	0.0774	TEC	0.026	0.02	0.01	0.0032
HEXACHLOROBENZENE	**118-74-1**	**0.02**	**NOAA**	**0.0067**	**0.33**	**0.248**	**0.082**
HEXACHLOROBUTADIENE	**87-68-3**	**0.0013**	**NOAA**	**0.0004**	**0.33**	**0.248**	**0.083**
HEXACHLOROCYCLOPENTADIENE	77-47-4	0.901	ESV	0.3	0.33	0.248	0.082
HEXACHLOROETHANE	67-72-1	1	EPA SQB	0.33	0.33	0.248	0.096
INDENO (1,2,3-CD)-PYRENE*	193-39-5	0.2	LEL	0.067	0.02	0.01	0.0019
ISOPHORONE	78-59-1	0.432	ESV	0.144	0.33	0.248	0.075
NAPHTHALENE*	91-20-3	0.176	TEC	0.058666667	0.02	0.01	0.0026
NITROBENZENE	**98-95-3**	**0.021**	**NOAA**	**0.007**	**0.33**	**0.248**	**0.091**
N-NITROSO DIPHENYLAMINE	**86-30-6**	**0.028**	**NOAA**	**0.009333333**	**0.33**	**0.248**	**0.219**
N-NITROSO-DI-N PROPYLAMINE	621-64-7	NC	None	NC	0.33	0.248	0.083
PENTACHLOROPHENOL	**87-86-5**	**0.017**	**NOAA**	**0.005666667**	**0.82**	**0.615**	**0.237**
PHENANTHRENE*	85-01-8	0.204	TEC	0.068	0.02	0.01	0.0018
PHENOL	**108-95-2**	**0.048**	**NOAA**	**0.016**	**0.33**	**0.248**	**0.156**
PYRENE*	129-00-0	0.195	TEC	0.065	0.02	0.01	0.0021
EXPLOSIVES							
1,3,5-Trinitrobenzene	99-35-4	NC	None	NC	0.1	0.05	0.0067
1,3-Dinitrobenzene	**99-65-0**	**0.00861**	**ESV**	**0.00287**	**0.1**	**0.05**	**0.0062**
2,4-Dinitrotoluene	**121-14-2**	**0.0144**	**ESV**	**0.0048**	**0.1**	**0.05**	**0.015**
2,6-Dinitrotoluene	**606-20-2**	**0.0398**	**ESV**	**0.013266667**	**0.1**	**0.05**	**0.027**
Nitrobenzene	**98-95-3**	**0.021**	**NOAA**	**0.007**	**0.1**	**0.05**	**0.022**
2,4,6-Trinitrotoluene	118-96-7	NC	None	NC	0.1	0.05	0.0067
2-Amino-4,6-Dinitrotoluene	35572-78-2	NC	None	NC	0.1	0.05	0.021
2-Nitrotoluene	88-72-2	NC	None	NC	0.1	0.05	0.012
3-Nitrotoluene	99-08-1	NC	None	NC	0.1	0.05	0.079
3,5-Dinitroaniline	618-87-1	NC	None	NC	0.1	0.05	0.0035
4-Amino-2,6-Dinitrotoluene	1946-51-0	NC	None	NC	0.1	0.05	0.017
4-Nitrotoluene	99-99-0	NC	None	NC	0.1	0.05	0.027
HMX	2691-41-0	NC	None	NC	0.1	0.05	0.0086
Tetryl	479-45-8	NC	None	NC	0.1	0.05	0.0054
RDX	121-82-4	NC	None	NC	0.1	0.05	0.0068
PETN	78-11-5	NC	None	NC	0.8	0.4	0.108
Nitroglycerin	55-63-0	NC	None	NC	0.8	0.4	0.124

Bolded rows indicate that the PSL is between the laboratory LOQ and LOD. The Partnering Team has agreed to accept this data for decision making if results below the LOQ are "J" qualified and the results are discussed in the RI.

Shaded and Bolded rows indicate the PSL is less than the LOD; therefore, the Partnering Team In cases where the LOD is greater than the PSL and the contaminant was not detected, the contaminant would not be retained as a COPC. However, the uncertainty associated with this decision would be discussed in the risk assessment. Moreover, a discussion regarding the likelihood of the presence of that contaminant (e.g. historic use) would be included in the risk assessment.

* indicates that these compounds will be reported from a Selective Ion Monitoring (SIM) analysis.

NC = No Criteria

Note: At the time of data evaluation, the most recent screening criteria will be utilized for the HHRA and ERA.

Screening Level Order of Preference :

1. Threshold Effect Concentration (TEC). MacDonald, et al, 2000.
2. Lowest Effects Level (LEL). Persaud, et al, 1993.
3. EPA Sediment Quality Benchmark (SQB). USEPA, 1996.
4. NOAA (Buchman, 2008) (freshwater selected first)
5. Secondary Chronic Value (SCV). Jones, et al, 1997.
6. Ecosystem Service Valuation (SEV). USEPA, 2003.
7. Los Alamos National Laboratory (LANL, 2009).

SAP Worksheet #16 -- Project Schedule/Timeline Table

(UFP-QAPP Manual Section 2.8.2)

Activity	Organization	Dates (MM/DD/YYYY)	
		Anticipated Date(s) of Initiation	**Anticipated Date of Completion**
Submit Draft RI SAP	Tetra Tech	5/11/2012	5/11/2012
Regulator Review	USEPA and MEDEP	5/11/2012	6/1/2012
Resolve Comments & Submit Final RI SAP	Tetra Tech	6/1/2012	6/29/2012
Field Investigation	Tetra Tech	10/8/2012	10/31/2012
Analytical Laboratory Analysis	Analytical Lab	10/10/2012	12/1/2012
Data Review and Validation	Tetra Tech	1/04/2012	2/2/2012
Submit Internal Draft RI Report	Tetra Tech	2/30/2012	2/30/2012
Navy Review	Navy	3/1/2012	3/29/2012
Resolve Comments & Submit Draft RI Report	Tetra Tech	3/29/2012	4/12/2013
Regulator Review	USEPA and MEDEP	4/15/2013	5/10/2013
Resolve Comments & Submit Final RI Report	Tetra Tech	5/10/2013	5/31/2013

SAP Worksheet #17 -- Sampling Design and Rationale

(UFP-QAPP Manual Section 3.1.1)

17.1 SAMPLING PROGRAM

The sampling strategy for Site 12 is based on both a judgmental (biased) and random (unbiased) sampling design. Sample locations were selected to target historical operations areas (berms) in which releases may have occurred and to confirm the absence of hazardous waste contaminants that may be associated with construction debris discovered in the subsurface during the 2010-2011 TCRA.

The objective of the sampling is to determine if residual contamination related to historical use of the site is present at levels of concern. If contamination is found at concentrations exceeding an acceptable level of risk, additional sampling may be necessary to provide statistical confidence for the analytical results and their spatial distribution. Based on the history of multiple EOD berms and operational activities at Site 12, the subject site was divided into six DUs, DU1 through DU4, which radiate out from the central berm area to the perimeter road, DU5, the pond, and DU6, site groundwater (Figure 11-1).

The study boundaries for the DUs were identified in Worksheet #11. Sampling locations within the study boundaries were selected to investigate areas of potential releases. Table 17-1 (below) presents a detailed list of the soil and sediment sampling investigations to be conducted at the DUs, including discrete soil/sediment and ISM soil sampling rationales. Table 17-2 (below) presents a detailed overview of the groundwater sampling investigations to be conducted for DU6. Figures 17-1 through 17-6 are the sample location maps for each DU described in Table 17-1. Sample locations will be subject to field conditions, and Anomaly Avoidance techniques in accordance with Worksheet #14 will be followed on site, which may result in the movement of sample locations slightly to avoid subsurface metallic anomalies that may represent MEC/MPPEH or construction debris.

17.2 FIELD QUALITY CONTROL SAMPLES

Field QC samples will be collected as part of the investigation, including field duplicates of discrete samples and replicates of ISM samples (detailed in Worksheet #14), and equipment rinsate blanks for non-dedicated sampling equipment. Worksheet #20 presents the field QC sample summary. In addition, additional sample volume will be collected as necessary for laboratory QC matrix spike (MS)/matrix spike duplicate (MSD) analyses and MS/duplicate sample analyses for discrete samples.

Table 17-1 Soil/Sediment Sampling Strategy

Decision Unit (DU) and Subareas[1]	Medium	Sampling Locations									Analytical[2, 3]	
		Discrete Samples		ISM Samples				Interval		Rationale	Analyses	Rationale
		Surface	*Sub-surface*	*No. of ISM Samples.*	*Grids or Locations*	*Grabs/ Increments[4]*	*Total increments*	*Depth (bgs)*	*Location [5]*			
DU1 – Existing Berm Mound	*Soil*	--	--	1	10	3	30	0 - 3 in	ISM - Collect three subsamples from 10 locations equally spaced along the inside wall of existing berm at the top, middle, and bottom of the berm face (30 increments total).	Potential elevated concentrations of MC anticipated and MEC likely present. Need to assess MC before MEC work to prevent "spreading" of contamination, if present. Moreover, the berm is an attractive nuisance necessitating long term MEC management issues to address erosion and other processes so excavation/removal will likely be recommended, and the proposed ISM sampling effort will aid in planning/costing (see Figures 11-1, 14-1, and 17-1).	Explosives (including propellant nitroglycerin) TAL metals	MC (explosives, nitroglycerin, and metals) are of concern based on historical operations.
				1	10	3	30	0 - 3 in	Replicate of above. Step-off 2 feet from samples collected above.			
				1	10	3	30	0 - 3 in	Replicate of above. Step-off 2 feet from samples collected above.			
				1	10	3	30	3 - 18 in	Co-located with the surface subsamples.			
				1	10	3	30	3 - 18 in	Replicate of subsurface sample. Co-located with the first replicate of the surface sample.			
DU2 – Overall Berm Area and Subareas (Including Subareas DU2A, DU2B, DU2C, DU2D, DU2E, and DU2F)	*Soil*	--	--	1	1	30	30	0 - 3 in	**DU2A-a – ISM:** Collect 30 increments from the DU2A-a Berm area (floor of berm). Composite samples from DU2A-a together. Do not combine with any other samples collected with DU2.	ISM Samples: Potential elevated concentrations of MC anticipated and MEC likely present in grids previously shown to have MEC/MPPEH and/or grids where historical berms are located based on aerial photographs. (See Figures 14-2 through 14-5, 17-2A, 17-2B, and 17-5). Assess presence of entire DU2 as an area of elevated contaminant concentration by comparison of ISM results with results from DU3 and DU4. Assess presence of any or all of sub-area DUs (DU2A through DU2E) as having elevated contaminant concentrations as compared with DU2 overall.	Explosives (including propellant nitroglycerin) TAL metals	MC (explosives, nitroglycerine, and metals) are of concern based on historical operations.
				1	1	30	30	0 - 3 in	Replicate of Sample DU2A-a-ISM above. Step-off 2 feet from samples collected above.			
				1	1	30	30	0 - 3 in	**DU2A-b – ISM:** Collect 30 increments from the DU2A-b Berm area (outside of berm but within DU2A boundary). Composite samples from DU2A-b together. Do not combine with any other samples collected with DU2.			
				1	1	30	30	0 - 3 in	Replicate of Sample DU2A-b-ISM above. Step-off 2 feet from samples collected above.			
		--	--	1	1	10	10	0 - 3 in	**DU2B – ISM:** Collect 10 increments from the DU2B Berm area. Composite samples from DU2B together. Do not combine with any other samples collected with DU2.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2B-ISM above. Step-off 2 feet from samples collected above.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2B-ISM above. Step-off 2 feet from samples collected above.			

Decision Unit (DU) and Subareas[1]	Medium	Sampling Locations									Analytical[2, 3]	
		Discrete Samples		ISM Samples				Interval		Rationale	Analyses	Rationale
		Surface	*Sub-surface*	*No. of ISM Samples.*	*Grids or Locations*	*Grabs/ Increments[4]*	*Total increments*	*Depth (bgs)*	*Location [5]*			
				1	1	10	10	0 - 3 in	DU2B Replicate of Sample DU2B-ISM above. Step-off 2 feet from samples collected above.			
DU2 – Overall Berm Area and Subareas (Including Subareas DU2A, DU2B, DU2C, DU2D, DU2E, and DU2F)	*Soil*	--	--	1	1	10	10	0 - 3 in	**DU2C – ISM:** Collect 10 increments from the DU2C Berm area. Composite samples from DU2C together. Do not combine with any other samples collected with DU2.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2C-ISM above. Step-off 2 feet from samples collected above.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2C-ISM above. Step-off 2 feet from samples collected above.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2C-ISM above. Step-off 2 feet from samples collected above.			
		--	--	1	1	10	10	0 - 3 in	**DU2D – ISM:** Collect 10 increments from the DU2D Berm area. Composite samples from DU2D together. Do not combine with any other samples collected with DU2.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2D-ISM above. Step-off 2 feet from samples collected above.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2D-ISM above. Step-off 2 feet from samples collected above.			
				1	1	10	10	0 - 3 in	Replicate of Sample DU2D-ISM above. Step-off 2 feet from samples collected above.			
		--	--	1	1	30	30	0 - 3 in	**DU2E – ISM:** Collect 30 increments from the DU2E Berm area. Composite samples from DU2E together. Do not combine with any other samples collected with DU2.			
				1	1	30	30	0 - 3 in	Replicate of Sample DU2E-ISM above. Step-off 2 feet from samples collected above.			
				1	1	30	30	0 - 3 in	Replicate of Sample DU2E-ISM above. Step-off 2 feet from samples collected above.			
				1	1	30	30	0 - 3 in	Replicate of Sample DU2E-ISM above. Step-off 2 feet from samples collected above.			

Decision Unit (DU) and Subareas[1]	Medium	Sampling Locations									Analytical[2, 3]	
		Discrete Samples		ISM Samples				Interval		Rationale	Analyses	Rationale
		Surface	*Sub-surface*	*No. of ISM Samples.*	*Grids or Locations*	*Grabs/ Increments[4]*	*Total increments*	*Depth (bgs)*	*Location [5]*			
DU2 – Overall Berm Area and Subareas (Including Subareas DU2A, DU2B, DU2C, DU2D, DU2E, and DU2F)	*Soil*	--	--	1	9	2, 4, 5, or 10 (varies by grid)	50	0 - 3 in	**DU2F-ISM:** Collect subsamples from non-berm areas outside of Identified Berm areas (DU2A-E). Collect subsamples from increment locations within a given grid (all subsamples composited into one ISM sample). Each grid has a specific number of samples as indicated on Figure 14-5 with 50 increments total for this DU. SUs - 100- by 100-foot grids E5-E7, F5-F7, and G5-G7 (excludes areas of E7 and F7 east of the perimeter road and excludes area designated as A-E)			
				1	9	2, 4, 5, or 10 (varies by grid)	50	0 - 3 in	Replicate of above. Step-off 2 feet from samples collected above.			
				1	9	2, 4, 5, or 10 (varies by grid)	50	0 - 3 in	Replicate of above. Step-off 2 feet from samples collected above.			
				1	9	2, 4, 5, or 10 (varies by grid)	50	0 - 3 in	Replicate of above. Step-off 2 feet from samples collected above.			
DU2 – Overall Berm Area and Subareas (Including Subareas DU2A, DU2B, DU2C, and DU2E)	*Soil*	--	20	--	--	--	--	1 – 5 ft	**DU2 – Discrete**: DU2A, B, C, and E Four discrete subsurface soil samples within four berms and evenly spaced; the current berm and three adjacent historical berms.	Discrete Samples: Potential elevated concentrations of MC anticipated and MEC likely present in grids previously shown to have MEC/MPPEH and/or grids where historical berms are located based on aerial photographs. Subsurface soil samples included because, typically, historical EOD activity at source area would have included subsurface detonations to tamp kick-outs (see Figures 17-2C).	Explosives (including propellant nitroglycerin) TAL metals	MC (explosives, nitroglycerine, and metals) are of concern based on historical operations

Decision Unit (DU) and Subareas[1]	Medium	Sampling Locations									Analytical[2, 3]	
		Discrete Samples		ISM Samples				Interval		Rationale	Analyses	Rationale
		Surface	*Sub-surface*	*No. of ISM Samples.*	*Grids or Locations*	*Grabs/ Increments[4]*	*Total increments*	*Depth (bgs)*	*Location [5]*			
DU3 – Intermediate Area Outside Berm Area	*Soil*	--	--	1	4	30	120	0 - 3 in	**DU3-a - ISM** - Collect subsamples from 30 locations within a given grid from each of four SU grids (all subsamples composited into one ISM sample, 120 increments total). SUs - D4, D7, F4, H4	Likely low concentrations of MC anticipated and lower density of MEC/MPPEH (surface has been cleared of MEC/MPPEH). ISM subsample locations were selected to bias the ISM soil sample from grids of terrestrial soil with or near previously identified MEC/MPPEH (see Figures 11-1, 14-6, and 17-3).	Explosives (including propellant nitroglycerin) TAL metals	MC (explosives, nitroglycerin, and metals) are of concern based on historical operations.
				1	4	30	120	0 - 3 in	Replicate of DU2-a. Step-off 2 feet from samples collected above.			
				1	4	30	120	0 - 3 in	**DU3-b - ISM** - Collect subsamples from 30 locations within a given grid from each of four SU grids (all subsamples composited into one ISM sample, 120 increments total). SUs - C5, H3, J7, and J8			
				1	4	30	120	0 - 3 in	Replicate of DU3-b. Step-off 2 feet from samples collected above.			
DU4 – Outer Area Outside Berm Area	*Soil*	--	--	1	5	30	150	0 - 3 in	Collect subsamples from 30 locations within a given grid from each of five grids (all subsamples composited into one ISM sample, 150 increments total). SU – B7, F1, K3,L5, and J9	Likely low concentrations of MC anticipated and lower density of MEC/MPPEH (surface has been cleared of MEC/MPPEH). ISM subsample locations were selected to bias the ISM soil sample from grids of terrestrial soil with or near previously identified MEC/MPPEH (see Figures 11-1, 14-6, and 17-3).	Explosives (including propellant nitroglycerin) TAL metals	MC (explosives, nitroglycerin, and metals) are of concern based on historical operations.
				1	5	30	150	0 - 3 in	Replicate of above. Step-off 2 feet from samples collected above.			
				1	5	30	150	0 - 3 in	Replicate of above. Step-off 2 feet from samples collected above. (See Figure 14-6)			

Decision Unit (DU) and Subareas[1]	Medium	Sampling Locations									Analytical[2, 3]	
		Discrete Samples		ISM Samples				Interval		Rationale	Analyses	Rationale
		Surface	*Sub-surface*	*No. of ISM Samples.*	*Grids or Locations*	*Grabs/ Increments[4]*	*Total increments*	*Depth (bgs)*	*Location [5]*			
DU5 – Pond	*Surface Water*	1	--	--	--	--	--	2 – 5 ft below water depth	Grab surface water sample(s) will be collected following determination of water depth and collection of water temperature readings every foot in the water column to determine if the water column is stratified. If the water column is stratified, collect two grab samples from both temperature zones at a central location in the pond. If the water column is not stratified, collect one grab surface water sample from central location in the pond and over the entire length of the water column. Surface water sample must be collected prior to sediment samples to reduce potential turbidity in the sample.	Characterization effort regarding handling of surface water during potential draining of the pond in support of the future MEC RI of the pond (See Section 14.1 for field parameters).	Explosives (including propellant nitroglycerin) TAL metals VOCs, SVOCs, and EPH/VPH	MC (explosives, nitroglycerin, perchlorate, metals,) are of concern based on historical operations. Confirm presence/absence of hazardous/fuel constituents.
	Sediment	4	--	--	--	--	--	0 - 6 in[6] (if available)	Measure pond depth at each sample location.	Locations spaced for coverage to determine if pond has been impacted by historical site operations. Locations are positioned along the centerline of the narrow historic pond (1978 aerial), which corresponds with the approximate centerline of the current pond. Sediment is a good media reflective of soil runoff as a whole for the site. Location M-12 is included because of visual observation of discoloration in sediment just before a culvert that appears to be an intermittent discharge point for Site 12. Soil samples are included with this DU to cover the historical extent of the pond (north and south) and disturbed areas to the northwest that are no longer under water (see Figures 11-1 and 17-4).		
		--	4	--	--	--	--	6 - 12 in[6] (if available)				
		1	--	--	--	--	--	0 - 6 in	Sample Location M-12: Collect sample sediment just before culvert located near Old Gurnet Road.			
	Soil	6	--	--	--	--	--	0 - 1 ft	Two from south of current pond where pond formerly extended but is not marshy, based on 1978 aerial photograph. Two from northern area of pond along the center line of the pond, where a disturbed area, no longer under water, which is evident on 1978 aerial photograph. Two from within the disturbed area evident on 1978 aerial photograph, west of the pond and the perimeter road (Grid K8)			
		--	6	--	--	--	--	1 - 5 ft [7]	Co-located with each discrete surface soil sample listed above.			
Total		**12**	**30**	**36**							s	

1 DUs were selected to account for anticipated differing types (MC or hazardous waste) and levels of contamination (berm area or outer kickout area), as well as anticipated different remedies.

2 Although two 55-gallon drums were identified onsite, hazardous waste constituents are not anticipated because similar drums are commonly used at EOD ranges to containerize munitions debris, and only construction debris was encountered during previous investigations and no suspect staining or potential hazardous waste debris (e.g., paint cans, transformers, oil, sludge) were identified on the ground surface or during trenching operations. However, the absence of constituents other than MC (VOCs, SVOCs, and EPH/VPH) needs to be confirmed in the subsurface. Therefore, sediment and groundwater sampling for these constituents is included where most likely to be encountered, in DU5 - Pond and DU6 – Groundwater/DU2 – Overall Berm Area. If these unanticipated contaminants of concern are detected in groundwater at concentrations greater than PSLs, the spatial location of the contamination will aid in identifying source areas, and additional sampling may be necessary.

3 Metals analysis for ISM samples will not be milled or ground prior to analysis. All sample preparation prior to the grinding step including sample disaggregation and sieving will be completed.

4 If a subsurface anomaly is identified by the UXO Escort, the increment location is to be moved to the nearest area clear of subsurface anomalies within the same increment grid or SU. Because the number and location of increments are dependent on following Anomaly Avoidance and numerous subsurface anomalies are expected, the number shown may not be achievable.

5 Note: all replicates will be blind to the laboratory and replicate sample design is explained in Worksheet # 14 and depicted in Figures 14-1 through 14-6.

6 Sediment intervals may not be attainable if a bedrock ledge is present and the vertical boundary based on actual site conditions may be smaller than the proposed sample intervals. For each of the four sample locations up to three attempts will be made to relocate the sample if no sediment is present, moving approximately 5 feet along the pond centerline. In addition, for the 6 to 12 inch below sediment interval, sample intervals may be adjusted to deeper intervals in the field based on evidence of visual observations or orlfactory (PID) readings indicting staining or possible contamination.

7 Subsurface sample discrete interval will be determined in the field from a non-saturated depth between 1 to 5 feet bgs or until bedrock is encountered, based on visual and olfactory observations (PID). If no visual or olfactory observations indicate, potential contamination samples will be collected from 1 to 3 feet bgs (unsaturated soil).

17.3 SUPPLEMENTAL GEOLOGICAL AND GEOPHYSICAL INVESTIGATION

A geological and geophysical (VLF electromagnetic [EM] and focused GPR) survey is planned for purposes of locating factures in the shallow subsurface across DU2 and up to 100 feet beyond its boundary and possibly detecting both east-east and north-south trending conductive bedrock fractures to help site three monitoring wells, as described in Table 17-2. The water table at Site 12 may be variable from monitoring well to monitoring well due to fracture flow. This information will be used in conjunction with fracture trace analysis and the 2003 bedrock survey information to refine the placement of shallow monitoring well locations.

A desktop fracture trace analysis will be performed by reviewing available geologic maps and aerial photography to identify surface expressions of possible fractures that may contain groundwater. A fracture map and rose diagram will be generated to determine the predominant fracture pattern at the site. A brief field investigation of bedrock exposures near Site 12 will be performed to collect strike and dip measurements of faults and fractures to ground-truth the desktop investigation. Strike and dip of bedrock fractures (e.g., foliation, joints), will be measured using a Brunton compass at bedrock outcrops located at Site 12. Spacing between parallel fractures and fracture coatings and/or fillings will be noted. Bedrock outcrops will be located using a GPS with submeter accuracy and depicted on an aerial photograph of Site 12. Bedrock fracture strike and dips will be compiled using a rose diagram to identify the predominant fracture directions at the site. In addition, an equal area stereonet will be prepared to determine the dip direction and magnitude associated with the predominant fracture directions.

A VLF survey is planned across DU2 and up to 100 feet beyond its boundary. Because the survey area is not large for VLF surveying, collect relatively closely spaced survey data without a large field effort. The survey will consist of collecting data at 25-foot intervals along 25-foot-spaced survey lines in both north-south and east-west directions. Surveying north-south is more effective in detecting east-west trending fractures and vice versa for east-west trending survey lines (more effective in detecting north-south fractures). VLF surveying relies on low-frequency EM signals from military transmitters that are becoming scarcer as new technology is developed. Therefore, if during survey mobilization, a reliable VLF signal is not being broadcast and received, a substitute EM survey may take the place of the VLF survey, if necessary.

The substitute EM survey would consist of multi-frequency EM surveying along 10-foot-spaced survey lines in one direction to search for conductive zones that could be attributed to potential fractures. Data are planned to be collected 10 times per second at a regular walking survey pace. Integrated DGPS measurements are planned to locate the EM data. Multi-frequency EM surveys typically employ a few

different simultaneous EM frequencies from a single survey instrument. Theoretically, lower frequencies can penetrate the ground more deeply than higher frequencies. Actual penetration depths depend on ground conductivity and will be unknown; however, relatively resistive ground is anticipated based on the sandy soil conditions expected for the site, and it is anticipated that EM signal penetration into the ground will be relatively deep (perhaps 20 to 25 feet).

Finally, a GPR survey will be focused on suspect VLF or EM anomalies that could potentially represent conductive fractures in accordance with SOP-14 (Ground-Penetrating Radar Surveys, Appendix A). A low-frequency antenna (i.e., 100 MHz) is planned for the GPR survey because lower-frequency EM signals can penetrate more deeply. The GPR survey will be conducted with survey lines across suspected possible conductive fractures.

17.4 SURFACE WATER SUPPLEMENTAL POND INVESTIGATION

Characterization of surface water in the pond to aid in planning the future MEC RI SAP will include inspection of the pond for evidence of surface inflows/outflows, collection of pond depth measurements to calculate the estimated volume of water in the pond, and collection of a single grab surface water sample to aid determination of possible discharge scenarios in accordance with Section 14.1 Pond Characterization and Sediment Sampling (Pond) and Table 17-1.

Table 17-2 Groundwater Geophysics and Sampling Strategy

Decision Unit (DU) & Subarea[1]	Location	Sampling Locations		Analytical	
		Number Samples	Rationale	Analyses	Rationale
DU6 – Groundwater	Locations refined following geophysics. First, a VLF fracture trace study will be conducted to determine locations of fractures in and around the source area (DU2), and then GPR will focus on further assessing monitoring well locations to select shallow fracture locations, where contamination is expected to be biased high in concentration. USEPA/MEDEP will be involved in determining monitoring well locations following the geophysics investigation. (see Figure 17-5)	Three shallow monitoring wells	Install three shallow monitoring wells (up to 30 feet bgs) to assess groundwater from the overall berm area that served as the historical operations area and so is most likely to be contaminated; one or more monitoring wells may be bedrock wells depending on site conditions [2][3].	Explosives (including propellant nitroglycerin) Perchlorate TAL metals VOCs SVOCs EPH/VPH	MC (explosives, nitroglycerin, perchlorate, and metals) are of concern based on historical operations. Hazardous waste constituents are not anticipated because only construction debris was encountered during previous investigations; however, the absence of constituents other than MC (VOCs, SVOCs, and EPH/VPH) needs to be confirmed. Groundwater is a media reflective of leaching from soil media as a whole. If unanticipated contaminants of concern are encountered in groundwater, the spatial location of the contamination and groundwater flow direction will aid in identifying the source area, and additional sampling may be necessary[2][3].
Remainder of Site	--	TBD	Depending on results from the initial DU6 monitoring wells, it is recognized that additional monitoring wells may be needed in a future phase of RI (or site remedy) for the remainder of the site.		

1 DUs were selected to account for anticipated differing types of contamination and levels of contamination, as well as anticipated different remedies.
2 Additional monitoring wells may need to be installed in the future, during a separate phase of RI work, if warranted, based on findings for DU6 and other DU soil results and considering spatial coverage, groundwater flow direction, and presence of previously encountered MEC/MPPEH areas of the site. A separate work plan would be developed for the installation of any monitoring wells beyond the three monitoring wells currently proposed for DU6.
3 If a subsurface anomaly is identified by the UXO Escort, the increment location is to be moved to the nearest area clear of subsurface anomalies within the same increment grid or SU. Because the number and location of increments are dependent on following Anomaly Avoidance and numerous subsurface anomalies are expected, the number shown may not be achievable.

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

(UFP-QAPP Manual Section 3.1.1)

Sampling Location (1)	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference(2)
DU1 – EXISTING BERM MOUND							
12D1-IS01	12D1-IS01-0003	Soil	ISM (10 stations X 3 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	SOP-02 SOP-03 SOP-05
12D1-IS01-R1	12ISM-R001	Soil	ISM (10 stations X 3 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D1-IS01-R2	12ISM-R002	Soil	ISM (10 stations X 3 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D1-IS02	12D1-IS02-1218	Soil	ISM (10 stations X 3 grabs = 30 increments)	3 – 18”	Explosives (Plus NG) TAL Metals	1 1	
12D1-IS02-R1	12ISM-R003	Soil	ISM (10 stations X 3 grabs = 30 increments)	3 – 18”	Explosives (Plus NG) TAL Metals	1 1	
DU2 – OVERALL BERM AREA (DU2A, DU2B, DU2C, DU2D, DU2E, and DU2F)							
12D2Aa-IS01	12D2Aa-IS01-0003	Soil	DU2A-a ISM (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	SOP-02 SOP-03 SOP-05
12D2Aa-IS01-R1	12ISM-R004	Soil	DU2A-a ISM-Replicate (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2Ab-IS01	12D2Ab-IS01-0003	Soil	DU2A-b ISM (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2Ab-IS01-R1	12ISM-R005	Soil	-DU2Ab ISM-Replicate (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	

Sampling Location (1)	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference(2)
12D2B-IS01	12D2B-IS01-0003	Soil	DU2B ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	SOP-02 SOP-03 SOP-05
12D2B-IS01-R1	12ISM-R006	Soil	DU2B ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2B-IS01-R2	12ISM-R007	Soil	DU2B ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2B-IS01-R3	12ISM-R008	Soil	DU2B ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2C-IS01	12D2C-IS01-0003	Soil	DU2C ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2C-IS01-R1	12ISM-R009	Soil	DU2C ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2C-IS01-R2	12ISM-R010	Soil	DU2C ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2C-IS01-R3	12ISM-R011	Soil	DU2C ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2D-IS01	12D2D-IS01-0003	Soil	DU2D ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2D-IS01-R1	12ISM-R012	Soil	DU2D ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	

Sampling Location (1)	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference(2)
12D2D-IS01-R2	12ISM-R013	Soil	DU2D ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	SOP-02 SOP-03 SOP-05
12D2D-IS01-R3	12ISM-R014	Soil	DU2D ISM (1 SU X 10 grabs = 10 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2E-IS01	12D2E-IS01-0003	Soil	DU2E ISM (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2E-IS01-R1	12ISM-R015	Soil	DU2E ISM (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2E-IS01-R2	12ISM-R016	Soil	DU2E ISM (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2E-IS01-R3	12ISM-R017	Soil	DU2E ISM (1 SU X 30 grabs = 30 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2F-IS01	12D2F-IS01-0003	Soil	DU2F ISM (1 SU X 50 grabs = 50 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2F-IS01-R1	12ISM-R018	Soil	DU2F ISM (1 SU X 50 grabs = 50 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2F-IS01-R2	12ISM-R019	Soil	DU2F ISM (1 SU X 50 grabs = 50 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D2F-IS01-R3	12ISM-R020	Soil	DU2F ISM (1 SU X 50 grabs = 50 increments)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	

Sampling Location [1]	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference[2]
DU2 – OVERALL BERM AREA (DU2A, DU2B, DU2C, and DU2E)							
12D2A-SB01	12D2A-SB01-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	SOP-02 SOP-03
12D2A-SB02	12D2A-SB02-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2A-SB03	12D2A-SB03-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2A-SB04	12D2A-SB04-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2B-SB01	12D2B-SB01-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2B-SB02	12D2B-SB02-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2B-SB03	12D2B-SB03-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2B-SB04	12D2B-SB04-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2C-SB01	12D2C-SB01-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2C-SB02	12D2C-SB02-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2C-SB03	12D2C-SB03-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2C-SB04	12D2C-SB04-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2E-SB01	12D2E-SB01-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2E-SB02	12D2E-SB02-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2E-SB03	12D2E-SB03-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	
12D2E-SB04	12D2E-SB04-XXXX[3]	Soil	Discrete	X – X' [2]	Explosives (Plus NG TAL Metals	1 1	

Sampling Location (1)	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference(2)
DU3 – INTERMEDIATE AREA OUTSIDE BERM AREA							
12D3a-IS01	12D3a-IS01-0003	Soil	ISM (4 grids x 30 grab = 120 increment)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	SOP-02 SOP-03 SOP-05
12D3a-IS01-R1	12IISM-R021	Soil	ISM (4 grid x 30 grab = 120 increment)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D3b-IS01	12D3b-IS01-0003	Soil	ISM (4 grid x 30 grab = 210 increment)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D3b-IS01-R1	12ISM-R022	Soil	ISM (4 grid x 30 grab = 210 increment)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
DU4 – OUTER AREA OUTSIDE BERM AREA							
12D4-IS01	12D4-IS01-0003	Soil	ISM (5 grid. x 30 grab = 150 increment)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	SOP-02 SOP-03 SOP-05
12D4-IS01-R1	12IISM-R023	Soil	ISM (5 grid x 30 grab = 150 increment)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
12D4-IS01-R2	12ISM-R024	Soil	ISM (5 grid x 30 grab = 150 increment)	0 – 3”	Explosives (Plus NG) TAL Metals	1 1	
DU5 – POND							
12D5-SD001	12D5-SD001-0006	Sediment	Discrete	0 – 6”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	2 2 2 2 2	SOP-02 SOP-03 SOP-06
	12D5-SD001-0612	Sediment	Discrete	6 – 12”			

Sampling Location [1]	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference[2]
12D5-SD002	12D5-SD02-0006	Sediment	Discrete	0 – 6”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	2 2 2 2 2	SOP-02 SOP-03 SOP-06
	12D5-SD02-0612	Sediment	Discrete	6 – 12”			
12D5-SD003	12D5-SD03-0006	Sediment	Discrete	0 – 6”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	2 2 2 2 2	
	12D5-SD03-0612	Sediment	Discrete	6 – 12”			
12D5-SD004	12D5-SD04-0006	Sediment	Discrete	0 – 6”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	2 2 2 2 2	
	12D5-SD04-0612	Sediment	Discrete	6 – 12”			
12D5-SD005 (Location M-12)	12D5-SD05-0006	Sediment	Discrete	0 – 6”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	1 1 1 1 1	
12D5-SB001	12D5-SS01-0006	Soil	Discrete	0 – 12”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	2 2 2 2 2	SOP-02 SOP-03
	12D5-SB01-0612	Soil	Discrete	X – X’ [3]			

Sampling Location [1]	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference[2]
12D5-SB002	12D5-SS02-0006	Soil	Discrete	0 – 12”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	2 2 2 2 2	
	12D5-SB02-0612	Soil	Discrete	X – X’ [3]			
12D5-SB003	12D5-SS03-0006	Soil	Discrete	0 – 12”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	2 2 2 2 2	
	12D5-SB03-0612	Soil	Discrete	X – X’ [3]			
12D5-SB004	12D5-SS04-0006	Soil	Discrete	0 – 12”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	1 1 1 1 1	
	12D5-SB04-0612	Soil	Discrete	X – X’ [3]			
12D5-SB005	12D5-SS05-0006	Soil	Discrete	0 – 12”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	1 1 1 1 1	
	12D5-SB05-0612	Soil	Discrete	X – X’ [3]			
12D5-SB006	12D5-SS06-0006	Soil	Discrete	0 – 12”	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	1 1 1 1 1	
	12D5-SB06-0612	Soil	Discrete	X – X’ [3]			
12SW-pond	12SW-pond	Surface Water	Grab	X – X’ [3]	Explosives (Plus NG) TAL Metals VOC SVOC EPH/VPH	1 1 1 1 1	SOP-06

Sampling Location [1]	ID Number	Matrix	ISM/Discrete	Target Depth (in bgs)	Analytical Group	Number of Samples	Sampling SOP Reference[2]
DU6 – GROUNDWATER							
12D6-MW01	12D6GW001-MMYY[4]	Groundwater	NA	Screened interval	Explosives (Plus NG) TAL Metals VOC SVOC Perchlorate EPH/VPH	1 1 1 1 1 1	SOP-01
12D6MW02	12D6GW002-MMYY[4]	Groundwater	NA	Screened interval	Explosives (Plus NG) TAL Metals VOC SVOC Perchlorate EPH/VPH	1 1 1 1 1 1	
12D6MW03	12D6GW003-MMYY[4]	Groundwater	NA	Screened interval	Explosives (Plus NG) TAL Metals VOC SVOC Perchlorate EPH/VPH	1 1 1 1 1 1	

1 Replicates (indicated by R1, R2, R3) are detailed in Worksheet #14. Each replicate sample is an individual samples and should **not** be combined with any other sample in a DU.
2 Sampling tasks are detailed in Worksheet #14. SOPs are included in Appendix A.
3 XXXX and X – X' represent the interval of the non-saturated sample in inches for ISM samples and in feet for discrete samples from 1 to 5 feet bgs or until bedrock or groundwater is encountered. Depth will be determined in the field based on visual and olfactory observations. If no visual or olfactory observations indicate potential contamination, samples will be collected from 1 to 3 feet bgs (unsaturated soil). For example, if sample is collected from 1 to 3 feet bgs, the depth will be recorded as 0103. For surface water, the sample interval will be determined based on the pond depth and the sample will be collected from midway between the water and sediment surfaces.
4 MMYY – month and year sample is collected.

Note: Field duplicate and MS/MSD samples will be collected at a frequency of 1 per 20 for discrete samples per medium per analyte for laboratory samples

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SAP Worksheet #19 -- Analytical SOP Requirements Table

(UFP-QAPP Manual Section 3.1.1)

MATRIX	ANALYTICAL GROUP	ANALYTICAL AND PREPARATION METHOD/ SOP REFERENCE	CONTAINERS (number, size, and type)	SAMPLE VOLUME (units)	PRESERVATION REQUIREMENTS (chemical, temperature, light protected)	MAXIMUM HOLDING TIME (preparation/ analysis)
Groundwater	VOCs (minus EDB)	SW-846 5030, 8260B/ CA-202	Three 40-mL volatile vials	40 milliliter (mL)	Hydrochloric acid (HCl) to pH< 2, cool to ≤ 6 °C	14 days to analysis
	Ethylene Dibromide (EDB)	EPA 504.1 / CA-326	Two 40-mL volatile vials	40 mL	0.5mL of sodium thiosulfate, no headspace, Cool to ≤ 6 ^{o}C.	14 days to analysis
	Metals (total)	SW-846 3010B, and 6020A, 7470A/ CA-604, CA-615, CA-627	One 1-liter (L) High Density Polyethylene (HDPE) bottle	100 mL	Nitric acid (HNO3) to pH < 2; Cool to ≤6 °C	6 months to analysis except mercury which is 28 days to analysis
	SVOCs (including low-level PAHs and 1,4-dioxane)	SW-846 3510C or 3520C, 8270D/8270D SIM/ CA-226, CA-213, CA-502	Two 1-L amber glass bottles	1000 mL	Cool to ≤6 °C	7 days for preparation; 40 days to analysis
	Explosives plus Nitroglycerin	SW-846 8330B Katahdin CA-402, CA-548	Two 1-L glass amber bottles	1L	Cool to above freezing and ≤ 6 °C	7 days until extraction, 40 days to analysis
	VPH	MADEP-VPH-04-1.1 Katahdin SOP CA-312	Two 40-mL glass vials	15 g	15 mL methanol, cool to ≤ 6 °C	28 days to analysis
	EPH	MADEP-EPH-04-1.1 Katahdin SOP CA-322, CA-511	Two 1-L amber glass bottles	1000 mL	5 mL of 1:1 HCl, cool to ≤ 6 °C	14 days to extraction, 40 days to analysis

MATRIX	ANALYTICAL GROUP	ANALYTICAL AND PREPARATION METHOD/ SOP REFERENCE	CONTAINERS (number, size, and type)	SAMPLE VOLUME (units)	PRESERVATION REQUIREMENTS (chemical, temperature, light protected)	MAXIMUM HOLDING TIME (preparation/ analysis)
Solid	VOCs	SW-846 5035, 8260B /CA-202, CA-214	Three Terra Core samplers	5 grams (g)	Sodium bisulfate or water and freeze to -10 ° C	48 hours from sampling to preparation, 14 days to analysis
			One 2-ounce (oz) wide-mouth jar for percent moisture	5 g	Cool to ≤6 °C	
	Metals	SW-846 3050B, and 6020A, 7471B/ CA-605, CA-611, CA-627	One 4-oz glass jar with a Teflon-lined lid	2 g	Cool to ≤6 °C	6 months to analysis for ICP metals; 28 days for mercury
	Metals – ISM (no grinding)	SW-846 3050B, and 6020A, 7471B/ CA-605, CA-611, CA-627	One plastic bag, 5-gallon bucket, or other container	1 to 4 kilograms	Cool to above freezing and ≤ 6 °C	6 months to analysis for ICP metals; 28 days for mercury
	SVOCs (including low level PAHs and 1,4-dioxane)	SW-846 3540C or 3550C, 8270D/8270D SIM/ CA-226, CA-213, CA-512, CA-526	One 4-oz glass jar with a Teflon-lined lid	30 g	Cool to ≤6 °C	14 days to extraction, 40 days to analysis
	Explosives plus Nitroglycerin	SW-846 8330B Katahdin CA-402	One 4-oz glass jar	30 g	Cool to above freezing and ≤ 6 °C	14 days until extraction, 40 days to analysis
	Explosives plus nitroglycerin – ISM (sample preparation – grinding only)	SW-846 8330B ALS 09-8330B Grinding	One plastic bag, 5-gallon bucket, or other container	1 to 4 kilograms	Cool to above freezing and ≤ 6 °C	14 days until extraction
	VPH	MADEP-VPH-04-1.1 Katahdin SOP CA-312	Two 40-mL glass vials	15 g	15 mL methanol, cool to ≤ 6 °C	28 days to analysis
	EPH	MADEP-EPH-04-1.1 Katahdin SOP CA-322, CA-511	4-oz wide-mouth jar	10 g	Cool to ≤ 6 °C	14 days to extraction, 40 days to analysis

MATRIX	ANALYTICAL GROUP	ANALYTICAL AND PREPARATION METHOD/ SOP REFERENCE	CONTAINERS (number, size, and type)	SAMPLE VOLUME (units)	PRESERVATION REQUIREMENTS (chemical, temperature, light protected)	MAXIMUM HOLDING TIME (preparation/ analysis)
Aqueous and Solid IDW[2]	TCLP Regulatory List Organics	SW-846 1311, SW-846 5030/8260B, SW-846 8151A, SW-846 3510C 8081A, SW-846 3510C/8270D	One 4-oz glass jar	25 g VOCs/ 100 g SVOC	Cool to 0 to 6 °C	14 days to TCLP extraction. Then14 days to analysis for VOC and 7 days until extraction, 40 days to analysis for all SVOCs
	TCLP Regulatory List Inorganics	SW-846 1311, SW-846 3010A/6010C, SW-846 7470A	One 4-oz glass jar	100 g	Cool to 0 to 6 °C	180 days to TCLP extraction, except mercury, which is 28 days. Then 180 days to analysis, except mercury, which is 28 days to analysis
	Ignitability	SW-846 1010A Unspecified	One 4-oz glass jar	unspecified	Cool to ≤ 6 °C	7 days to analysis
			One 500 mL plastic bottle	unspecified	Cool to ≤ 6 °C	7 days to analysis
	pH	SW-846 9045D	One 4-oz glass jar with a Teflon-lined lid	20 g	Cool to < 6 °C	Analyze as soon as possible
		SW-846 9040C	One 500-mL plastic bottle	50 mL	Cool to ≤6 °C	Analyze as soon as possible
	Reactive Cyanide Reactive Cyanide	SW-846 9012A	One 4-oz glass jar	5 g	Cool to 0 to 6 °C	14 days to analysis
			One 250-mL plastic bottle	50 mL	Sodium hydroxide to a pH > 12; Cool to ≤6 °C	14 days to analysis
	Reactive Sulfide Reactive Sulfide	SW-846 9030, 9034	One 4-oz glass jar	25 g	Cool to 0 to 6 °C	7 days to analysis
		SM4500S-2 CF	One 250-mL plastic bottle	250 mL	Zinc Acetate and Sodium Hydroxide; Cool to ≤ 6°C	7 days to analysis

EDB – Ethylene dibromide.

1 Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet #23).
2 IDW sample analyses are presented on this worksheet for the utilization of field personnel. QC information is not presented in any of the remaining worksheets for these samples.
3 Incremental sampling with milling (grinding) is required to obtain accurate mean site concentrations with minimal data variability (while minimizing analytical costs); however, for some metals, milling can increase detected concentration because milling releases metals that occur naturally in the soil. Therefore, metals analysis for ISM samples will not be milled or ground prior to analysis. All sample preparation prior to the grinding step including sample disaggregation and sieving will be completed. In addition, malleable metals such as aluminum, copper, and lead could smear in the grinding chamber during the milling process if a significant amount of larger particle size metal particles are present in the ISM samples. This could result in low results in some samples and carryover issues in other samples. The Project Team will review field and laboratory observations regarding the presence of metallic particles and compare the concentrations of aluminum, copper, and lead in the replicate/triplicate samples from DU1 to determine if this may be an issue and if warranted discussed in the uncertainty analysis during the risk assessment.

SAP Worksheet #20 -- Field Quality Control Sample Summary Table

(UFP-QAPP Manual Section 3.1.1)

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates(1)	No. of MS/MSDs(2)	No. of Replicates for Incremental(3)	No. of Equip. Blanks(4)	No. of VOC Trip Blanks(3)	Total No. of Samples to Lab
Discrete Sampling								
Surface Soil	Explosives	6	1	1/1	--	1	--	8
	TAL Metals	6	1	1/1	--	1	--	8
	VOCs	6	1	1/1	--	1	1	9
	SVOCs	6	1	1/1	--	1	--	8
	EPH/VPH	6	1	1/1	--	1	--	8
Subsurface Soil	Explosives	26	2	2/2	--	--	--	7
	TAL Metals	26	2	2/2	--	--	--	7
	VOCs	6	1	1/1	--	--	1	8
	SVOCs	6	1	1/1	--	--	--	7
	EPH/VPH	6	1	1/1	--	--	--	7
Sediment	Explosives	9	1	1/1	--	1	--	11
	TAL Metals	9	1	1/1	--	1	--	11
	VOCs	9	1	1/1	--	1	1	12
	SVOCs	9	1	1/1	--	1	--	11
	EPH/VPH	9	1	1/1	--	1	--	11
Groundwater	Explosives	3	1	1/1	--	1	--	5
	TAL Metals	3	1	1/1	--	1	--	5
	VOCs	3	1	1/1	--	1	1	6
	SVOCs	3	1	1/1	--	1	--	5
	EPH/VPH	3	1	1/1	--	1	--	5
	Perchlorate	3	1	1/1	--	1	--	5
Surface Water	Explosives	1	--	--	--	--	--	1
	TAL Metals	1	--	--	--	--	--	1
	VOCs	1	--	--	--	--	1	2
	SVOCs	1	--	--	--	--	--	1
	EPH/VPH	1	--	--	--	--	--	1
ISM Sampling								
Surface Soil	Explosives	12	--	--	24	1	--	35
	TAL Metals	12	--	--	24	1	--	35
Subsurface Soil	Explosives	1	--	--	--	--	--	1
	TAL Metals	1	--	--	--	--	--	1

1 Duplicates will be collected at a rate of 1 per 20 discrete samples.
2 MS/MSD samples will be collected at a rate of 1 per 20 discrete samples. Although MS/MSDs are not typically considered field QC samples, they are included here because location determination is often established in the field. The MS/MSDs are not included in the total number of samples sent to the laboratory.
3 ISM replicate samples are listed in Worksheets #s 17 and 18.
4 Equipment blanks will be collected at a frequency of one per type of equipment per medium (one soil – from the hand auger, one sediment – dredge, 1 groundwater – pump, 1 ISM – core sampler).
5 Trip blanks will be collected at a frequency of one per cooler containing VOC samples.

SAP Worksheet #21 -- Project Sampling SOP References Table

(UFP-QAPP Manual Section 3.1.2)

Reference Number	Title, Revision Date, and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
SOP-01	SA-1.1 - Groundwater Sample Acquisition and Onsite Water Quality Test	Tetra Tech	Multi-parameter water quality meter, such as a Horiba U-22 or YSI.	Y	Contained in Appendix A
SOP-02	SA-1.3 - Soil Sampling	Tetra Tech	Stainless steel or disposable trowel, long-handled sampling device (Hand Auger)	Y	
SOP-03	GH-1.5 Borehole and Sample Logging	Tetra Tech	None	N	
SOP-04	SA-7.1 Decontamination Of Field Equipment	Tetra Tech	None	N	
SOP-05	Incremental Sampling (Is) Methodology For Soil and/or Sediment for the military munitions response program	Tetra Tech	None	Y	
SOP-06	SA-1.2 Surface Water And Sediment Sampling	Tetra Tech	Stainless steel or disposable trowel, long-handled sampling device (Wildco Hand Core Sampler)	Y	
SOP-07	GH-2.8 Groundwater Monitoring Well Installation	Tetra Tech	Drill rig (provided by Drilling subcontractor)	Y	
SOP-08	GH-1.3 - Soil And Rock Drilling Methods	Tetra Tech	Drill rig (provided by Drilling subcontractor)	Y	
SOP-09	GH-1.2 - Evaluation of Existing Monitoring Wells and Water Level Measurement	Tetra Tech	Water level indicator	Y	
SOP-10	SA-6.1 - Non-Radiological Sample Handling	Tetra Tech	Field logbook, sample log sheets, boring logs, Chain of custody	N	
SOP-11	GPS Data Collection And Transfer	Tetra Tech	Trimble GPS Unit – Hand held	N	
SOP-12	SA-6.3 - Field Documentation	Tetra Tech	Field logbook, sample log sheets, boring logs, Chain of custody	N	
SOP-13	CT-4 0 - Sample Nomenclature	Tetra Tech	none	N	
SOP-14	GH-3.4 - Ground-Penetrating Radar Surveys	Tetra Tech	GPR	N	

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

(UFP-QAPP Manual Section 3.1.2.4)

Field Equipment	Activity[1]	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference[2]	Comments
Magnetic Locator (Schonstedt GA-52Cx)	Visual Inspection/ Operational	Beginning of day and after battery change	Operating properly	Replace battery, replace instrument	Tetra Tech UXO Escort	Worksheet #14.	
GPS	Positioning	Beginning and end of each day used	Accuracy: sub-meter horizontal dilution of precision (HDOP) <3, number of satellites at least four.	Wait for better signal, replace unit, or choose alternate location technique	Tetra Tech FOL or designee	SOP-11	SOP located in Appendix A.
Multi-Parameter Water Quality Meter (YSI 600 Series or similar)	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance.	Operator correction or replacement	Tetra Tech FOL or designee	SOP-01	SOP located in Appendix A.
PID	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance	Operator correction or Replacement	Tetra Tech FOL or designee	Operation according to manufacturer's instructions	See Manufacturer's Instruction included with equipment.
Turbidity Meter (LaMotte 2020 or similar)	Visual Inspection Calibration/ Verification	Daily Beginning and end of day	Manufacturer's guidance; calibrations must bracket expected values. Initial Calibration Verification (ICV) must be <10 nephelometric turbidity units (NTUs).	Operator correction or replacement	Tetra Tech FOL or designee	SOP-01	SOP located in Appendix A.

1 Activities may include calibration, verification, testing, maintenance, and/or inspection.
2 From the Project Sampling SOP References table (Worksheet #21).

SAP Worksheet #23 -- Analytical SOP Reference Table

(UFP-QAPP Manual Section 3.2.1)

Laboratory SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Variance to Quality Systems Manual (QSM)? (Y/N)	Modified for Project Work? (Y/N)
CA-202	Analysis of Volatile Organic Compounds by Purge and Trap GC/MS: SW-846 Method 8260, 05/11, Revision 12.	Definitive	Soil, sediment, groundwater and aqueous QC samples/ VOCs	Gas Chromatography (GC)/ Mass Spectroscopy (MS)	Katahdin	N	N
CA-213	Analysis of Semivolatile Organic Compounds by: SW-846 Method 8270 – Modified for Selected Ion Monitoring (SIM), 05/11, Revision 9.	Definitive	Soil, sediment, groundwater and aqueous QC samples / low-level PAHs and 1,4-dioxane)	GC/MS	Katahdin	N	N
CA-214	Closed-System Purge-And-Trap And Extraction For Volatile Organics In Soil And Waste Samples Using SW846 Method 5035, 09/08, Revision 5.	Definitive	Soil /VOCs	Tekmar, Arcon, Encon	Katahdin	NA	N
CA-226	Analysis of SVOAs by Capillary Column GC/MS: SW-846 Method 8270D, 01/12, Revision 3.	Definitive	Soil, sediment, groundwater and aqueous QC samples/ SVOCs	GC/MS	Katahdin	N	N
CA-326	Extraction and Analysis of EDB (1,2-Dibromoethane), DBCP (1,2-Dibromo-3-chloropropane), and 1,2,3-TCP (1,2,3-Trichloropropane) in Water buy EPA Method 504.1, 04/10, Revision 8.	Definitive	Groundwater/EDB	GC/ Electron Capture Detector (ECD)	Katahdin	N	N
CA-502	Preparation of Aqueous Samples For Extractable Semivolatile Analysis, 10/09, Revision 6.	Definitive	Groundwater and aqueous QC samples / SVOCs and low level PAHs and 1,4-dioxane Extraction	NA / Extraction	Katahdin	NA	N
CA-512	Preparation of Sediment/Soil Samples By Sonication Using Method 3550 For Subsequent Extractable Semi-Volatiles Analysis, (Revision 8, 08/10)	Definitive	Soil and Sediment / SVOCs and low level PAHs and 1,4-dioxane Extraction	NA / Extraction	Katahdin	NA	N
CA-526	Preparation of Sediment/Soil Samples By Soxhlet Extraction Using Method 3540 For Subsequent Extractable Semivolatile Analysis, (Revision 7, 08/10)	Definitive	Soil and sediment/ SVOCs and low level PAHs and 1,4-dioxane Extraction	NA / Extraction	Katahdin Analytical Services, Inc.	NA	N
CA-402	Determination of Nitroaromatics And Nitramines By HPLC Method 8330 (Revision 6, 01/12)	Definitive	Soil, sediment, groundwater, and aqueous QC samples / Explosives plus nitroglycerin	High-Pressure Liquid Chromatography (HPLC)/ Ultraviolet (UV) Detector	Katahdin	N	N
CA-548	Preparation of Aqueous And Solid Samples For Explosive Analysis By Method 8330 (Revision 0, 01/12)	Definitive	Soil, sediment, groundwater, and aqueous QC samples / Explosives plus nitroglycerin Extraction	NA / Extraction	Katahdin	N	N
ALS 09-8330B Grinding	Mechanical Grinding of Solids/Soils Through the Use of a Ring Puck Mill (Revision 4, 09/13/09)	Definitive	Soil and sediment/ Explosives (IS samples only)	NA – Preparatory Laboratory Grinding	ALS	N	N
CA-604	Acid Digestion of Aqueous Samples by EPA Method 3010 for ICP and ICP-MS Analysis of Total or Dissolved Metals (Revision 5, 04/10)	Definitive	Groundwater and aqueous QC samples / Metals Digestion	NA – Sample Preparation	Katahdin	NA	N
CA-605	Acid Digestion of Solid Samples by USEPA Method 3050 for Metals by ICP-AES and GFAA (Revision 5, 09/10)	Definitive	Soil and sediment / Metals Digestion	NA – Sample Preparation	Katahdin	NA	N
CA-611	Digestion and Analysis Of Solid Samples For Mercury By USEPA Method 7471 (Revision 8, 12/10)	Definitive	Soil and sediment / Mercury Digestion and Analysis	Cold Vapor Atomic Absorption (CVAA)	Katahdin	N	N
CA-615	Digestion and Analysis Of Aqueous Samples For Mercury By USEPA Method 7470 (Revision 6, 05/11)	Definitive	Groundwater, and aqueous QC samples / Mercury Digestion/ Analysis	CVAA	Katahdin	N	N
CA-627	Trace Metals Analysis By ICP-MS Using USEPA Method 6020 (Revision 7, 04/10)	Definitive	Soil, sediment, groundwater, and aqueous field QC samples/ Metals	Inductively Coupled Plasma - Mass Spectroscopy(ICP-MS)	Katahdin	N	N
CA-312	Method for the Determination of Volatile Petroleum Hydrocarbons (MADEP - VPH) (Revision 8, 12/11)	Definitive	Soil, sediment, groundwater, and aqueous QC samples / VPH	GC/ FID/ PID	Katahdin	NA	N
CA-322	Method for the Analysis of Extractable Petroleum Hydrocarbons by MADEP – EPH (Revision 10, 01/12)	Definitive	Soil, sediment, groundwater, and aqueous QC samples / EPH	GC/FID	Katahdin	NA	N
CA-511	Extraction of Petroleum Hydrocarbons From Samples for Analysis by MADEP – EPH Methods (Revision 7, 04/10)	Definitive	Soil, sediment, groundwater, and aqueous QC samples / EPH Extraction	NA/ Extraction	Katahdin	NA	N
BR-LC-004	Perchlorate in Waters and Soils, 07/28/11, Rev. 4	Definitive	Shallow/Perched Groundwater and Aqueous QC samples/ Perchlorate	Liquid Chromatography/Mass Spectrometry/Mass Spectrometry (LC/MS/MS)	TestAmerica - Burlington	N	N

1. Katahdin SOPs begin with CA. The BR-LC-004 SOP is from Test America and the ALS SOP is from ALS.

SAP Worksheet #24 -- Analytical Instrument Calibration Table

(UFP-QAPP Manual Section 3.2.2)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/MS VOCs	Initial Calibration (ICAL) - A minimum five-point calibration is required.	Calibrate the instrument when it is received and after a major change or if the daily calibration fails.	VOCs (except vinyl chloride): The average Response Factors (RFs) for System Performance Check Compound (SPCCs) must be ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane and ≥ 0.10 for chloromethane, 1,1-dichloroethane and bromoform. The Percent RSD (%RSD) for RFs for Calibration Check Compounds (CCCs) must be ≤ 30%, and one option below must be met: Option 1) %RSD < 15% for all other compounds. If not met: Option 2) Linear least squares regression: correlation coefficient (r) ≥ 0.995. Option 3) Non-linear regression: coefficient of determination (r^2) ≥ 0.99 (6 points for second order).	Repeat calibration if criterion is not met	Analyst, Supervisor	CA-202
	ICV (Second Source)	Once after each ICAL.	The Percent Recovery (%R) must be within 80-120% for all target compounds.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.	Analyst, Supervisor	
	Retention Time (RT) Window Position Establishment	Once per ICAL for each analyte and surrogate.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial continuing calibration verification is used.	NA.	Analyst, Supervisor	
	Evaluation of Relative Retention Times (RRTs)	With each sample.	RRT of each target analyte must be within ± 0.06 RRT units.	Correct problem, then rerun ICAL.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/MS VOCs (con't)	Continuing Calibration Verification (CCV)	Analyze a standard at the beginning of each 12-hour shift after a bromofluorobenzene (BFB) tune.	VOCs (except vinyl chloride): The RFs for SPCCs must be ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane and ≥ 0.10 for chloromethane, 1,1-dichloroethane and bromoform. The %D for all target compounds and surrogates must be ≤ 20% (D = Difference or Drift).	DoD project level approval must be obtained for each of the failed analytes or CA must be taken. Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since last acceptable CCV.	Analyst, Supervisor	
	BFB Tune	Every 12 hours.	Criteria listed in Section 7.3, current revision of SOPs CA-202 and CA-220.	Retune and/or clean source.	Analyst, Supervisor	
GC/ECD-EDB	ICAL - six-point calibration	Instrument receipt, major instrument change, when CCV does not meet criteria.	One of the options below: Option 1: %RSD for each analyte must be ≤ 20%; Option 2: linear least squares regression: r must be ≥ 0.995; Option 3: non-linear regression: r^2 must be ≥ 0.99 (6 points shall be used for second order).	Repeat ICAL and/or perform necessary equipment maintenance. Check calibration standards. Reanalyze affected data.	Analyst, Supervisor	CA-326
	Quality Control Sample	Immediately following calibration.	%R must within 70%-130%.	(1) Reanalyze standard (2) Reprepare standard Reprepare standard from fresh stock.	Analyst, Supervisor	
	MDL Check Standard	After initial calibration.	%R must within 60%-140%.	(3) Reanalyze standard (4) Reprepare standard Reprepare standard from fresh stock.	Analyst, Supervisor	
	Dibromochloromethane Check sample	After initial calibration.	Peak separation from Ethylene dibromide	Instrument Maintenance	Analyst, Supervisor	
	CCV	Every 12-hour shift of operation. At the beginning and/or end of analytical sequence.	%R must within 70%-130%.	Evaluate the samples: If the %R >130 and sample results are <LOQ, narrate. If %R<70 or >130 only on one channel, narrate. If %R<70 or >130 and is likely a result of matrix interference, narrate. Otherwise, reanalyze all samples after the first failing CV.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/MS (full scan) SVOCs GC/MS (SIM) PAHs+ 1,4-dioxane	ICAL - A minimum five-point calibration is required.	Instrument receipt, instrument change (new column, source cleaning, etc.), when CCV is out of criteria. Six-point initial calibration for all analytes.	SVOCs (except PAHs): The average RF for SPCCs must ≥ 0.050; The %RSD for RFs for CCCs must be ≤30%, and one option below must be met: Option 1) %RSD < 15% for all other compounds. If not met: Option 2) Linear least squares regression: r ≥ 0.995 Option 3) Non-linear regression: r^2 ≥ 0.99 (6 points for second order). PAHs - Project-specific criteria: The average RF for all target compounds must be ≥0.050. The %RSD for all target compounds must be ≤30%. If not met, Option 2 or Option 3 above must be met.	Recalibrate and/or perform the necessary equipment maintenance. Check the calibration standards. Reanalyze the affected data.	Analyst, Supervisor	CA-226, CA-213
	Breakdown Check (DDT only)	At the beginning of each 12-hour analytical sequence.	The degradation must be ≤ 20% for DDT to verify inertness of the injection port.	Correct the problem then repeat breakdown check. No samples shall be run until degradation is ≤20% for DDT.	Analyst, Supervisor	
	ICV (Second Source)	Once after each ICAL.	The %R must be within 80-120% for all target compounds.	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat ICAL.	Analyst, Supervisor	
	RT Window Position Establishment	Once per ICAL for each analyte and surrogate.	Position shall be set using the midpoint standard of the ICAL curve when ICAL is performed. On days when ICAL is not performed, the initial CCV is used.	NA.	Analyst, Supervisor	
	Evaluation of RRTs	With each sample.	RRT of each target analyte must be within ± 0.06 RRT units.	Correct problem, then rerun ICAL.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
	CCV	Analyze a standard at the beginning of each 12-hour shift after a decafluorotriphenylphosphine (DFTPP) tune.	SVOCs (except PAHs): The RF for SPCCs must be ≥0.050; The %D for all target compounds and surrogates must be ≦ 20%D (D = Difference or Drift) PAHs - Project-specific criteria: The RF for all target compounds must be ≥0.050. The %D for all target compounds and surrogates must be ≦ 25%D. (D = Difference or Drift)	DoD project level approval must be obtained for each of the failed analytes or CA must be taken. Correct problem, then rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since last acceptable CCV.	Analyst, Supervisor	
	DFTPP Tune	Every 12 hours	Criteria listed in Section 7.4, current revision of SOPs CA-204 and CA-213	Retune and/or clean source.	Analyst, Supervisor	
ICP-MS - Metals	Tune	Daily prior to calibration	Mass calibration must be within 0.1 amu of true value, Resolution must be < 0.9 amu at 10% peak height. RSD must be ≤ 5% for at least four replicate analyses.	Perform necessary equipment maintenance.	Analyst, Supervisor	CA-627
	ICAL	Daily prior to sample analysis.	4 point calibration plus blank – The r must be ≥ 0.995.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards.	Analyst, Supervisor	
	ICV (Second Source)	Once after each ICAL, and before beginning a sample run.	The %R must be within 90-110% of true value for all analytes.	Do not use results for failing elements unless the ICV > 110% and the sample results are non-detect. Investigate and correct problem.	Analyst, Supervisor	
	Calibration Blank	Before beginning a sample sequence, after every 10 samples and at end of the analysis sequence.	No analytes detected > LOD. For negative blanks, absolute value < LOD.	Correct the problem, then re-prepare and reanalyze.	Analyst, Supervisor	
	CCV	After every 10 samples and at the end of each run sequence.	The %R must be within 90-110% of true value for all analytes.	Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
ICP-MS – Metals (continued)	Low-level Calibration Check Standard	Daily, after one-point ICAL.	The %R must be within 80-120% of true value for all analytes.	Do not use results for failing elements, unless low-level standard recovery.> upper limit and sample results are non-detect. Investigate and correct the problem.	Analyst, Supervisor	
Mercury Analyzer	ICAL	Upon instrument receipt, major instrument change, at the start of each day.	Initial Calibration, 5 points plus a calibration blank - r ≥ 0.995.	Recalibrate and/or perform necessary equipment maintenance. Check calibration standards.	Analyst, Supervisor	CA-611, CA-615
	ICV (Second Source)	Once after each ICAL, prior to beginning a sample run.	The %R must be within 90-110% of true value for mercury.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL.	Analyst, Supervisor	
	Calibration Blank	Before beginning a sample sequence, after every 10 samples and at end of the analysis sequence.	No analytes detected > LOD. For negative blanks, absolute value < LOD.	Correct problem. Re-prep and reanalyze calibration blank. All samples following the last acceptable calibration blank must be reanalyzed.	Analyst, Supervisor	
	CCV	Beginning and end of each run sequence and every 10 samples.	The %R must be within 90-110% of true value for mercury.	Correct problem, rerun calibration verification. If that fails, then repeat ICAL. Reanalyze all samples since the last successful calibration verification.	Analyst, Supervisor	
HPLC/UV Explosives plus nitroglycerin	ICAL – A minimum of a five-point calibration curve is analyzed	Prior to sample analysis.	The apparent signal-to-noise ratio at the LOQ must be at least 5:1. If linear regression is used, Linear Regression Correlation Coefficient (r) must be ≥ 0.995. If Internal Standardization is used, relative RSD for target analytes must be ≤ 15%.	Correct problem, then repeat ICAL. No samples can be run without a valid ICAL.	Analyst, Supervisor	Katahdin CA-402
	ICV - Second source	Once after each ICAL, prior to beginning a sample run.	The %R of all target analytes and surrogates must be within 80-120% of the true value.	Correct problem and verify second source standard. Rerun ICV. If that fails, correct problem and repeat ICAL. No samples may be run until calibration has been verified.	Analyst, Supervisor	
	CCV	Prior to sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All target analytes and surrogates must be ≤20 %D of the expected value from the ICAL.	Correct problem, rerun CCV. If that fails, then repeat ICAL. Reanalyze all samples since last successful CCV.	Analyst, Supervisor	
	Interference Check Standard (ICS) - ICSA & ICSB	At the beginning of an analytical run and every 12 hours.	The absolute value of ICS A recoveries must be < LOD and ICS B %Rs must be within 80-120 % of the true value.	Terminate analysis, locate and correct problem, reanalyze ICS, reanalyze all samples.	Analyst, Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
GC/FID/PID VPH	ICAL	Instrument receipt, major instrument change, when Continuing Calibration Verification does not meet criteria.	The %RSD of all project compounds must be ≤ 25%.	Investigate and repeat ICAL.	Analyst, Supervisor	SOP CA-312
	ICV (Second Source)	Once after each initial calibration.	The %D for all project compounds must be ≤25% of the expected value.	(1) Reanalyze standard. (2) Reprepare standard. Reprepare standard from fresh stock.	Analyst, Supervisor	
	CCV	Analyze prior to sample analysis, after every 20 samples and at end of sequence.	The %D must be ≤25%.	Evaluate the samples: If the %D >25% (30% for n-nonane) and sample results are <LOQ, narrate. Otherwise, reanalyze all samples after last acceptable CV.	Analyst, Supervisor	
GC/FID EPH	ICAL	Prior to sample analysis.	The %RSD must be ≤ 25% or the r must be ≥0.99.	Investigate and repeat ICAL.	Analyst, Supervisor	SOP CA-322
	ICV (Second Source)	Immediately following calibration.	The %D for all project compounds must be ≤25% of the expected value.	(1) Reanalyze standard. (2) Reprepare standard. Reprepare standard from fresh stock.	Analyst, Supervisor	
	CCV	After every 20 samples; If calibration curve previously analyzed, analyze daily before samples.	The %D must be ≤30% for n-nonane and ≤25%for all other analytes. The closing CCV may have four analytes> than 25%D, but must be < 40%D.	Evaluate the samples: If the %D >25% (30% for n-nonane) and sample results are < LOQ, narrate. Otherwise, reanalyze all samples after last acceptable CCV.	Analyst, Supervisor	
HPLC/ESI/ MS Perchlorate HPLC/ESI/	Tune	Prior to ICAL and after any mass calibration or maintenance is performed.	Tuning standards must contain the analytes of interest and meet acceptance criteria outlined in the laboratory SOP.	Re-tune instrument. If the tuning will not meet acceptable criteria, an instrument mass calibration must be performed and the tuning redone. Sample analysis shall not proceed without acceptable tuning.	Analyst/ Supervisor	TA SOP- BR-LC-004
	ICAL – A minimum of a 5-point calibration is prepared.	Upon instrument receipt, major instrument change, or when the CCV does not meet criteria.	The %RSD for RFs must be ≤ 20 % or r must be ≥ 0.995. The concentration corresponding to the absolute value of the Y-intercept of the calibration curve must be ≤ LOD.	Correct problem then repeat ICAL. No samples may be run until ICAL has passed.	Analyst/ Supervisor	
	ICV – Second Source	Once after each ICAL, prior to the analysis of samples.	The %R must be within 85-115%.	Correct problem and verify ICV. If that fails, correct problem and repeat ICAL. No samples can be analyzed until ICV has been verified.	Analyst/ Supervisor	
	CCV	Before sample analysis and after every 10 field samples, and at the end of the sequence.	Low-range standard: Perchlorate must be within 50-150 %R. Mid-range standard: Perchlorate must be within 85-115 %R.	Correct problem and rerun CCV. If that fails, repeat ICAL and re-analyze all samples analyzed since the last successful CCV.	Analyst/ Supervisor	

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference[1]
	Limit of Detection Verification (LODV) (per batch)	Prior to sample analysis and at the end of the sequence. It can be analyzed after every 10 samples to reduce the re-analysis rate.	The %R must be within 70-130%. Per the DoD QSM for Environmental Laboratories, Version 4.1, the perchlorate spike concentration must be approximately 2 times the LOD.	Correct problem, rerun LODV and all samples since last successful LODV. If a sample with perchlorate concentration at or between the LOD and LOQ is bracketed by a failing LODV, it must be re-analyzed. A sample with a concentration above the LOQ can be reported. Results cannot be reported without a valid LODV.	Analyst/ Supervisor	

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

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

(UFP-QAPP Manual Section 3.2.3)

Instrument/Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person[2]	SOP Reference
GC/MS	Check pressure and gas supply daily. Bake out trap and column, manual tune if BFB not in criteria, change septa as needed, cut column as needed, change trap as needed. Other maintenance specified in lab Equipment Maintenance SOP.	VOCs	Ion source, injector liner, column, column flow, purge lines, purge flow, trap.	Prior to ICAL and/or as necessary.	Acceptable ICAL or CCV	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	CA-202
GC/ECD	Check pressure and gas supply daily. Change septa and/or liner as needed, replace or cut column as needed. Other maintenance specified in lab Equipment Maintenance SOP.	EDB	Injector liner, septa, column, column flow.	Prior to ICAL and/or as necessary.	Acceptable calibration or CCV	Correct the problem and repeat calibration or CCV	Analyst, Supervisor	CA-326
GC/MS	Check pressure and gas supply daily. Manual tune if DFTPP not in criteria, change septa as needed, change liner as needed cut column as needed. Other maintenance specified in lab Equipment Maintenance SOP	SVOCs/PAHs and 1,4-dioxane	Ion source, injector liner, column, column flow	Prior to ICAL and/or as necessary.	Acceptable ICAL or CCV	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	CA-213, CA-226
ICP-MS	Clean torch assembly and spray chamber when discolored or when degradation in data quality is observed. Clean nebulizer, check argon, and replace peristaltic pump tubing as needed. Other maintenance specified in lab Equipment Maintenance SOP.	Metals	Torch, nebulizer, spray chamber, pump tubing	Prior to ICAL and as necessary	Acceptable ICAL or CCV	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	CA-627
Mercury Analyzer	Replace peristaltic pump tubing, replace mercury lamp, replace drying tube, clean optical cell and/or clean liquid/gas separator as needed. Other maintenance specified in lab Equipment Maintenance SOP.	Mercury	Tubing, sample probe, optical cell	Prior to ICAL and as necessary	Acceptable ICAL or CCV	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	CA-611, CA-615

Instrument/Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	CA	Responsible Person[2]	SOP Reference
HPLC/UV	Check and sonicate pump valves as needed. Backflush column as needed. Replace analytical column or guard column as needed. Sonicate and replace solvent with every use. Replace the UV lamp as needed. Check and replace seal-pak as needed.	Explosives plus nitroglycerin	Column flow, pressure.	Prior to ICAL and as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	Katahdin CA-402
GC/PID/FID	Replace or cut GC column as needed. Bake out trap and column. Change trap as needed.	VPH	Trap, column, column flow.	Prior to ICAL and/or as necessary.	Acceptable ICAL or CCV	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	SOP CA-312
GC/FID	Check pressure and gas supply daily. Change septa and/or GC injector glass liner as needed. Replace or cut GC column as needed. Other maintenance specified in lab Equipment Maintenance SOP.	EPH	Injector liner, septa, column, column flow.	Prior to ICAL and/or as necessary.	Acceptable ICAL or CCV	Correct the problem and repeat ICAL or CCV.	Analyst, Supervisor	SOP CA-322
HPLC/ESI/MS	Clean the source and capillary needle. Change analytical column as needed, change mobile phase when insufficient for run or contamination, change inlet filters as needed for contamination.	Perchlorate	Check pump pressure, check for leaks, check for adequate mobile phase.	Prior to ICAL and as necessary.	Acceptable ICAL and CCV.	Correct the problem and repeat ICAL or CCV.	Analyst/ Supervisor	BR-LC-004

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

SAP Worksheet #26 -- Sample Handling System

(UFP-QAPP Manual Appendix A)

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): FOL or designee / Tetra Tech
Sample Packaging (Personnel/Organization): FOL or designee / Tetra Tech
Coordination of Shipment (Personnel/Organization): FOL or designee / Tetra Tech
Type of Shipment/Carrier: Overnight courier service (FedEx)
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Sample Custodians / Katahdin, Test America, and ALS
Sample Custody and Storage (Personnel/Organization): Sample Custodians / Katahdin, Test America, and ALS
Sample Preparation (Personnel/Organization): Preparation laboratory staff / Katahdin, Test America, and ALS
Sample Determinative Analysis (Personnel/Organization): HPLC Lab, and ICP-MS Lab personnel / Katahdin
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): 60 days from submittal of final report
Sample Extract/Digestate Storage (number of days from extraction/digestion): 60 days from submittal of final report
Biological Sample Storage (Number of days from sample collection): NA
SAMPLE DISPOSAL
Personnel/Organization: Sample Custodians / Katahdin, Test America, and ALS
Number of Days from Analysis: 60 days from submittal of final report

SAP Worksheet #27 – Sample Custody Requirements Table

(UFP-QAPP Manual Section 3.3.3)

Field Sample Custody Procedures

Katahdin and Test America will provide pre-preserved sample containers for sample collection. Following sample collection into the appropriate bottleware, all samples will be immediately placed on ice in a cooler. Glass sample containers will be enclosed in bubble wrap to protect the bottleware during shipment. The cooler will be secured using strapping tape along with a signed custody seal. Sample coolers will be delivered to a local courier location for priority overnight delivery to the selected laboratory for analysis. Samples will be preserved as appropriate based on the analytical method. Samples will be maintained at ≤ 6 °C (but not frozen) until delivery to the laboratory(s). Proper custody procedures will be followed throughout all phases of sample collection and handling.

Chain-of-custody protocols will be used throughout sample handling to establish the evidentiary integrity of samples. These protocols will be used to demonstrate that the samples were handled and transferred in a manner that would eliminate possible tampering. Samples for the laboratory will be packaged and shipped in accordance with SOP-10.

Chain-of-Custody Procedures

After collection, each sample will be maintained in the sampler's custody until formally transferred to another party (e.g., FedEx). For all samples collected, chain-of-custody forms will document the date and time of sample collection, the sampler's name, and the names of all others who subsequently held custody of the sample. Specifications for chemical analyses will also be documented on the chain-of-custody form. SOP-10 provides further details on the chain-of-custody procedure. Chain-of-custody requirements are also documented with instructions contained in each shipment from the laboratory.

Laboratory Sample Custody Procedures

The laboratory sample custody procedures (receipt of samples, archiving, and disposal) documented in Katahdin and Test America SOPs will be followed. Coolers will be received and checked for proper temperature. A sample cooler receipt form will be completed to note conditions and any discrepancies. The chain-of-custody form will be compared to the sample containers received to verify correctness. Samples will be logged into the laboratory information management system (LIMS) and assigned a unique log number that can be tracked through processing. The Tetra Tech PM or Project Chemist will be notified of any problems by the Katahdin Laboratory PM on the same day that the issue is identified.

Sample Designation System

Each sample collected for analysis will be assigned a unique sample tracking number. This number will consist of a two-segment alphanumeric code that identifies the site, the sample type (sample medium or QC sample designation), the sample location, and the sample depth indicator. SOP13 addresses sample identification nomenclature not described below. All pertinent information regarding sample identification will be recorded in the field logbooks and on sample log sheets where appropriate.

The alphanumeric coding system to be used is as follows:

Site Identifier:

12 = Site 12

DU Identifier:

D1 = DU1

D2 = DU2, etc.

Sample Medium:

SS = Surface Soil

SB = Subsurface Soil

GW = Groundwater

SD = Sediment

IS = Incremental Soil Sample

QA/QC Sample Designation:

RB = Rinsate Blank

FD = Field Duplicate

TB = Trip Blank

Sample Location:

The names of all planned sample locations are identified in Worksheet #18.

Surface and subsurface soil samples will be assigned a two to three-digit consecutive location number. This will then be followed by the soil sample depth indicated by a four-digit number. The first two digits

will represent the upper limit of the sample depth interval (rounded to the nearest foot), and the last two digits will represent the lower limit of the sample depth interval.

Groundwater samples will be assigned a three-digit consecutive location number based on the monitoring well ID.

Sediment samples will be assigned a two-digit consecutive location number. For sediment samples, the two-digit location number will be followed by the sample depth indicated by a four-digit number. The first two digits will represent the upper limit of the sample depth, and the last two digits will represent the lower limit of the sample depth interval (depths will be rounded to the nearest inch).

QC Sample Number:

All QC samples will be assigned a sequential sample number. For example, the first equipment rinsate blank collected July 16, 2012, will be assigned the tracking number 12RB071612-01. Field duplicate, MS, and MSD samples will be collected from the same location. The field duplicate will be given the same type of sample designation as the samples so that it will be “blind” to the laboratory. The sampling time recorded on the chain-of-custody form, labels, and tags for the duplicate samples will be 0000. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory).

All pertinent information regarding sample identification will be recorded in the field logbooks and on sample log sheets, where appropriate.

SAP Worksheet #28 -- Laboratory QC Samples Table

(UFP-QAPP Manual Section 3.4)

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**VOCs**
Analytical Method/ SOP Reference	**SW-846 8260B/ CA-202**

QC Sample	Frequency/ Number	Method/SOPQC Acceptance Limits	CA	Person(s) Responsible for CAs	DQI	MPC
Method Blank	One per batch of 20 or less.	All target analytes must be ≤ ½ LOQ, except common lab contaminants, which must be < LOQ.	Investigate source of contamination. Rerun method blank prior to analysis of samples if possible. Evaluate the samples and associated QC: if blank results are above LOQ, report sample results which are < LOQ or > 10X the blank concentration. Reanalyze blank and samples >LOQ and < 10X the blank.	Analyst, Supervisor	Accuracy/Bias/ Contamination	Same as Method/SOP QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**VOCs**
Analytical Method/ SOP Reference	**SW-846 8260B/ CA-202**

QC Sample	**Frequency/ Number**	**Method/SOPQC Acceptance Limits**	**CA**	**Person(s) Responsible for CAs**	**DQI**	**MPC**
Surrogate	Four per sample: Dibromofluoromethane 1,2-dichloroethane-d4 Toluene-d8 Bromofluorobenzene	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G.	If sample volume available, and within hold time reanalyze.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)	One per batch of 20 or less.	%Rs must meet the DoD QSM for Environmental Laboratories Version 4.2 limits as per Appendix G. RPD must be ≤ 30% (for LCS/Laboratory Control Sample Duplicate [LCSD], if LCSD is performed). In-house statistical laboratory limits are used when DoD QSM v. 4.2 does not specify.	Correct problem, then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. Contact Tetra Tech if samples cannot be reanalyzed within hold time.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**VOCs**
Analytical Method/ SOP Reference	**SW-846 8260B/ CA-202**

QC Sample	**Frequency/ Number**	**Method/SOPQC Acceptance Limits**	**CA**	**Person(s) Responsible for CAs**	**DQI**	**MPC**
Internal Standard (IS)	Four per sample- Pentafluorobenzene 1,4-Difluorobenzene, Chlorobenzene-d5 1,4-dichlorobezene-d4	Retention times for internal standards must be ± 30 seconds and the responses within -50% to +100% of last calibration verification (12 hours) for each IS.	Inspect mass spectrometer or gas chromatograph for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
MS/MSD	One per sample delivery group (SDG) or every 20 samples.	%Rs should meet the DoD QSM Version 4.2 limits as per Appendix G. RPD must be ≤ 30%	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable, re-prepare the samples and QC.	Analyst, Supervisor	Precision/ Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.
Results between DL and LOQ	NA	Apply “J” qualifier to results between DL and LOQ.	NA	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Groundwater**
Analytical Group	**EDB**
Analytical Method/ SOP Reference	**EPA 504.1 / CA-326**

QC Sample:	**Frequency/ Number**	**Method/SOP QC Acceptance Limits**	**CA**	**Person(s) Responsible for CA**	**DQI**	**MPC**
Method Blank	One per preparation batch of 20 or fewer samples of similar matrix.	No target compounds ½ LOQ	(1) Investigate source of contamination (2) Evaluate the samples and associated QC: i.e. If the blank results are above the LOQ, report sample results which are < LOQ or > 10X the blank concentration. Otherwise, reprep a blank and the remaining samples.	Analyst, Supervisor	Bias/ Contamination	Same as Method/SOP QC Acceptance Limits.
Surrogates	One per sample	%R within laboratory's statistically-derived QC limits of 36-123.	(1) Reextract sample if no detected surrogate recovery (2) Notate sample result if matrix interference indicated	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
LCS	Equivalent to 10% of the sample load, or 1 per batch of samples extracted, whichever is greater	%R within method limits of 70-130.	(1) Evaluate the samples and associated QC: i.e. If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the surrogate recoveries in the LCS are low but are acceptable in the blank and samples, narrate. If the LCS recovery is high but the sample results are < LOQ, narrate. Otherwise, reprep a blank and the remaining samples.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
MS/MSD	One per sample delivery group (SDG) or every 20 samples. (If requested by client)	%R should be within the same limits as for the LCS. RPD should be ≤ 30%.	(1) Evaluate the samples and associated QC: i.e. If the LCS results are acceptable, narrate. (2) If both the LCS and MS/MSD are unacceptable, reprep the samples and QC.	Analyst, Supervisor	Precision/ Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Groundwater**
Analytical Group	**EDB**
Analytical Method/ SOP Reference	**EPA 504.1 / CA-326**

QC Sample:	**Frequency/ Number**	**Method/SOP QC Acceptance Limits**	**CA**	**Person(s) Responsible for CA**	**DQI**	**MPC**
Second Column Confirmation	All positive results must be confirmed.	Results between primary and second column must be RPD ≤ 40%.	None. Apply qualifier if RPD >40% and discuss in the case narrative. The higher of the two results will be reported unless matrix interference is apparent.	Analyst, Supervisor	Precision	Same as Method/SOP QC Acceptance Limits.
Results between DL and LOQ	NA	Apply "J" qualifier to results between DL and LOQ.	NA	Analyst, Supervisor	Accuracy	Same as QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**SVOCs (including low-level PAHs and1,4-dioxane)**
Analytical Method/ SOP Reference	**SW-846 8270D/ 8270D SIM CA-226, CA-213**

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparation batch of twenty or fewer samples of similar matrix.	No target compounds should be > ½ the LOQ except common lab contaminants, which should be, no target compounds should be > the LOQ.	(1) Investigate source of contamination (2) Re-prepare and analyze method blank and all samples processed with the contaminated blank.	Analyst, Supervisor	Accuracy/Bias/Contamination	Same as Method/SOP QC Acceptance Limits.
Surrogates	Six per sample (scan): 2-Fluorophenol Phenol-d6 Nitrobenzene-d5 2-Fluorobiphenyl 2,4,6-Tribromophenol Terphenyl-d14 3 per sample (SIM) 2-methylnaphthalene-d10, Fluorene-d10, Pyrene-d10.	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G. SIM surrogate recoveries with in laboratory control limits.	(1) Check chromatogram for interference; if found, then flag data. (2) If not found, then check instrument performance; if problem is found, then correct and reanalyze. (3) If still out, then re-extract and analyze sample. (4) If reanalysis is out, then flag data.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**SVOCs (including low-level PAHs and1,4-dioxane)**
Analytical Method/ SOP Reference	**SW-846 8270D/ 8270D SIM CA-226, CA-213**

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
LCS	One per batch of 20 or less.	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G. RPD must be ≤ 30% (for LCS/LCSD, if LCSD is performed). In-house statistical laboratory limits are used when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available Contact client if samples cannot be reanalyzed within hold time.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
IS	Six per sample – 1,4-Dichlorobenzene-d4 Naphthalene-d8 Acenaphthene-d10 Phenanthrene-d10 Chrysene-d12 Perylene-d12	Retention times for internal standards must be ± 30 seconds and the responses within -50% to +100% of last calibration verification (12 hours) for each IS.	Reanalyze affected samples.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**SVOCs (including low-level PAHs and1,4-dioxane)**
Analytical Method/ SOP Reference	**SW-846 8270D/ 8270D SIM CA-226, CA-213**

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
MS/MSD	One per SDG or every 20 samples.	%Rs should meet the DoD QSM Version 4.2 limits as per Appendix G. RPD should be ≤ 30%. In-house statistical laboratory limits are used when DoD QSM v. 4.2 does not specify.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met. If both the LCS and MS/MSD are unacceptable, re-prepare the samples and QC.	Analyst, Supervisor	Precision/Accuracy/ Bias	Same as Method/SOP QC Acceptance Limits.
Results between DL and LOQ	NA	Apply “J” qualifier to results between DL and LOQ.	NA	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**Metals (including mercury)**
Analytical Method / SOP Reference	**SW-846 6020A,7470A, 7471B/ CA-604, CA-611, CA-615, CA-627**

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per digestion batch of 20 or fewer samples.	No analytes detected > ½ the LOQ.	Correct the problem. If method blank is >½ the LOQ, then: 1) Report sample results that are <LOD or sample results >10x the blank concentration without CA. 2) For samples with results > LOD and < 10x the contaminated blank result, re-prepare/re-digest and reanalyze the method blank and associated samples.	Analyst, Supervisor	Accuracy/Bias/Contamination	Same as Method/SOP QC Acceptance Limits.
LCS	One per digestion batch of 20 or fewer samples.	Water and soil sample %Rs must be between 80 and 120%.	Redigest and reanalyze all associated samples for affected analyte.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Duplicate Sample	One per preparation batch of twenty or fewer samples of similar matrix.	The RPD should be within ≤20% for duplicate samples for both water and soils.	Narrate any results that are outside control limits.	Analyst, Supervisor	Precision	Same as Method/SOP QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous QC samples**
Analytical Group	**Metals (including mercury)**
Analytical Method / SOP Reference	**SW-846 6020A,7470A, 7471B/ CA-604, CA-611, CA-615, CA-627**

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
MS	One per digestion batch of 20 or fewer samples.	%R should be within 80-120%if sample < 4x spike added.	Flag results for affected analytes as estimated	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
IS (applies to SW-846 6020A only)	Every sample.	For each sample, IS intensity must be within 30-120% of that of initial calibration standard.	Reanalyze affected samples.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
ICP Serial Dilution	One per preparation batch of 20 or fewer samples of similar matrix.	If original sample result is at least 50x the instrument detection limit, five-fold dilution must agree within ± 10% of the original result.	Flag results for affected analytes for all associated samples as estimated	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Post-Digestion Spike (does not apply to mercury)	One is performed when serial dilution fails or target analyte concentration(s) in all samples are < 50x LOD.	The %R must be within 75-125% of expected value to verify the absence of an interference. Spike addition should produce a concentration of 10-100x LOQ.	Flag results of samples of same matrix as estimates in SDG narrative.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Results between DL and LOQ	NA	Apply “J” qualifier to results between DL and LOQ.	NA	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous field QC samples**
Analytical Group	**Explosives plus nitroglycerin**
Analytical Method/ SOP Reference	**SW-846 8330B** **Katahdin CA-402**

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per batch of 20 or fewer samples per matrix.	No analytes ≥½ LOQ.	Correct problem. If required, re-prep and reanalyze method blank and all samples processed with the contaminated blank. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Bias/Contamination	Same as QC Acceptance Limits.
Soil Grinding Blank	Between each sample.	No analytes ≥½ LOQ.	All blank results must be reported and the affected samples must be flagged accordingly if blank criteria are not met.	Analyst, Supervisor	Bias/Contamination	Same as QC Acceptance Limits.
Surrogates	All field and QC samples. One per sample: 1,2-Dinitrobenzene	%R must be within 30-150%.	Investigate the problem. If the recovery looks like it is affected by the sample matrix, the sample may be reinjected to confirm matrix interference. When the sample has no detectable surrogate recovery, the sample should be reextracted.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
LCS/LCSD (LCSD not required)	One per batch of 20 or fewer samples per matrix.	%R for target analytes must be within DoD QSM Version 4.2limits as per Appendix G. In-house statistical laboratory limits are used when DoD QSM v. 4.2 does not specify.	Correct problem, then re-prep and reanalyze LCS and all samples processed with the failed analytes. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.	Analyst, Supervisor	Accuracy/Bias Precision also, if LCSD is analyzed	Same as QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and aqueous field QC samples**
Analytical Group	**Explosives plus nitroglycerin**
Analytical Method/ SOP Reference	**SW-846 8330B** **Katahdin CA-402**

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
MS/MSD	One per batch of 20 or fewer samples per matrix.	%R for target analytes should be within DoD QSM Version 4.2 limits as per Appendix G. RPD between MS and MSD should be ≤20%. In-house statistical laboratory limits are used when DoD QSM v. 4.2 does not specify.	Evaluate the sample spiked for matrix interference and flag the data as necessary. Examine the project DQOs and the Laboratory PM will contact the Tetra Tech Project Chemist to determine the course of action.	Analyst, Supervisor	Accuracy/Bias Precision	Same as QC Acceptance Limits.
Second Column Confirmation	All positive results must be confirmed.	Results between primary and second column - RPD must be ≤ 40%.	None. Report from both columns. Apply “J” flag if RPD >40% and discuss in the case narrative.	Analyst, Supervisor	Precision	Same as QC Acceptance Limits.
Results between the DL and LOQ	NA.	Apply “J” qualifier to results detected between DL and LOQ.	None.	Analyst, Supervisor	Accuracy	Same as QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and Aqueous QC Samples**
Analytical Group	**VPH**
Analytical Method/ SOP Reference	**MADEP VPH/ Katahdin SOP CA-312**

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Method Blank	One per preparation batch of 20 or fewer samples of similar matrix.	All target analytes must be ≤ LOQ.	Investigate source of contamination. Evaluate the samples and associated QC: i.e., if the blank results are above the LOQ, report samples results which are < LOQ and >10X the blank. Otherwise, reprepare a blank and the remaining samples.	Analyst, Supervisor	Bias/ Contamination	Same as QC Acceptance Limits.
Surrogates	Every field and QC sample. One per sample: 2,5-Dibromotoluene	Water and soil: %Rs must be within 70-130%.	Reanalyze; present both sets of data.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
LCS LCSD (not required)	One per preparation batch of 20 or fewer samples of similar matrix.	Water and soil: %Rs must be within 70-130%.	Evaluate the samples and associated QC: i.e. If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the surrogate recoveries in the LCS are low but are acceptable in the blank and samples, narrate. If the LCS recovery is high but the sample results are < LOQ, narrate. Otherwise, reprepare a blank and the remaining samples.	Analyst, Supervisor	Accuracy/Bias Precision also, if LCSD analyzed	Same as QC Acceptance Limits.
MS/MSD	One per SDG or every 20 samples.	Water and soil: %Rs should be within 70-130%. RPD between MS and MSD should be ≤50%.	Evaluate the samples and associated QC: i.e. If the LCS results are acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprepare the samples and QC.	Analyst, Supervisor	Accuracy/Bias/ Precision	Same as QC Acceptance Limits.

Matrix	**Soil, sediment, groundwater, and Aqueous QC Samples**
Analytical Group	**EPH**
Analytical Method/ SOP Reference	**MADEP EPH/ Katahdin SOP CA-322**

QC Sample	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	DQI	MPC
Method Blank	One per preparation batch of 20 or fewer samples of similar matrix.	All target analytes must be ≤ LOQ.	Investigate source of contamination. Evaluate the samples and associated QC: i.e., if the blank results are above the LOQ, report samples results which are < LOQ and >10X the blank. Otherwise, reprepare a blank and the remaining samples.	Analyst, Supervisor	Bias/ Contamination	Same as QC Acceptance Limits.
Surrogates	Every field and QC sample. Three per sample: ortho-Terphenyl, 5-alpha-androstane, 2-Fluorobiphenyl	Water and soil: %Rs must be within 40-140%.	Reanalyze; present both sets of data.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits.
LCS LCSD (not required)	One per preparation batch of 20 or fewer samples of similar matrix.	Water and soil: %Rs must be within 40-140%. RPD between LCS and LCSD must be ≤ 25%, if analyzed.	Evaluate the samples and associated QC: i.e. If an MS/MSD was performed and acceptable, narrate. If an LCS/LCSD was performed and only one of the set was unacceptable, narrate. If the surrogate recoveries in the LCS are low but are acceptable in the blank and samples, narrate. If the LCS recovery is high but the sample results are < LOQ, narrate. Otherwise, reprepare a blank and the remaining samples.	Analyst, Supervisor	Accuracy/Bias Precision also, if LCSD is analyzed	Same as QC Acceptance Limits.
MS/MSD	One per SDG or every 20 samples.	Water and soil: %Rs should be within 40-140%. RPD should be ≤ 50%.	Evaluate the samples and associated QC: i.e. If the LCS is acceptable, narrate. If both the LCS and MS/MSD are unacceptable, reprepare the samples and QC.	Analyst, Supervisor	Accuracy/Bias/ Precision	Same as QC Acceptance Limits.

Matrix	**Shallow/Perched Groundwater and Aqueous QC Blanks**
Analytical Group	**Perchlorate**
Analytical Method/ SOP Reference	**SW-846 6850 / TA SOP- BR-LC-004**

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Isotope Ratio $^{35}Cl/^{37}Cl$	Every sample, batch QC sample, and standard.	Monitor for the daughter ion at masses 83/85. Theoretical ratio ~ 3.06. Ratio must be within 2.3 to 3.8.	If criteria are not met, the sample must be rerun. If the sample was not pretreated, the sample should be re-extracted using cleanup procedures. If, after cleanup, the ratio still fails, use alternative techniques to confirm presence of perchlorate.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
IS	Every sample, batch QC sample, standard, instrument blank, and method blank.	Measured ^{18}O IS area must be within 50-150% of the average IS area counts of the ICAL. Relative Retention Time (RRT) of the perchlorate ion must be within 0.98-1.02.	Rerun the sample at increasing dilutions until the 50-150% acceptance criteria is met. If criteria cannot be met with dilution, interference is suspected - use additional pretreatment steps.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.
Interference Check Sample (ICS)	One per batch to verify method performance at the matrix conductivity threshold (MCT). At least one ICS must be analyzed daily.	The %R must be within 70-130% of true value.	Correct problem and re-analyze all samples in that batch. Replace cleanup filters or column if necessary. No samples may be reported that are associated with a failing ICS.	Analyst, Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits.

Matrix	**Shallow/Perched Groundwater and Aqueous QC Blanks**
Analytical Group	**Perchlorate**
Analytical Method/ SOP Reference	**SW-846 6850 / TA SOP- BR-LC-004**

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Reagent Blank	Prior to calibration, after over-range samples, and at the end of the analytical sequence.	No perchlorate detected > ½ LOQ.	Re-analyze reagent blank (until no carryover is observed) and all samples processed since the contaminated blank. Results may not be reported without a valid reagent blank.	Analyst, Supervisor	Bias/ Contamination	Same as Method/SOP QC Acceptance Limits.
Method Blank	One per preparatory batch of 20 or fewer samples.	Perchlorate must be ≤ ½ LOQ.	Investigate source of contamination and evaluate the samples and associated QC: i.e. If the blank results are above ½ LOQ, then report sample results which are non-detect. Otherwise, re-prepare blank and associated samples.	Analyst, Supervisor	Bias/ Contamination	Same as Method/SOP QC Acceptance Limits.
LCS (Laboratory Control Sample Duplicate [LCSD] not required)	One per preparatory batch of 20 or fewer samples. LCS must be spiked at the LOQ.	%Rs must be between 80-120. RPD should be ≤ 15%, if LCSD is analyzed.	If the %R of a target analyte in the LCS is greater than the upper control limit, and there are no positive findings for that compound, no further action is taken. Otherwise, re-analyze the LCS and affected samples or flag the results. If the %R of any target analyte is below the lower control limit, re-analyze the LCS and affected samples.	Analyst, Supervisor	Accuracy/ Bias Precision also, if LCSD is analyzed	Same as Method/SOP QC Acceptance Limits.

Matrix	**Shallow/Perched Groundwater and Aqueous QC Blanks**
Analytical Group	**Perchlorate**
Analytical Method/ SOP Reference	**SW-846 6850 / TA SOP- BR-LC-004**

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix. The MS and MSD must be spiked at the LOQ.	%Rs should be between 80-120. RPD should be ≤ 15%	Flag the parent sample for failed analytes, which exceed the acceptance criteria.	Analyst, Supervisor	Accuracy/ Bias/ Precision	Same as Method/SOP QC Acceptance Limits.

SAP Worksheet #29 -- Project Documents and Records Table

(UFP-QAPP Manual Section 3.5.1)

Document	Location Maintained
Sample Collection Documents and Records: • Field logbook (and sampling notes) • Field sample forms (e.g., boring logs, sample log sheets, drilling logs, etc.) • Chain-of-custody records • Sample shipment airbills • Equipment calibration logs • Photographs • Field Task Modification Request forms • SAP • Field Sampling SOPs • Health and Safety Plan	Tetra Tech project file; results will be discussed in subject document
Laboratory Documents and Records in the Form of Analytical Data Packages: • Sample receipt/login form • Sample storage records • Sample preparation logs • Equipment calibration logs • Sample analysis run logs • Reported results for standards, QC checks, and QC samples • Data completeness checklists • Telephone logs • Extraction/clean-up records • Raw data • EDDs	Tetra Tech project file; long-term data package storage at third-party commercial document storage firm. Laboratory documents will be included in the hardcopy and Portable Document Format (PDF) deliverables from the laboratory. Laboratory data deliverables will be maintained in the Tetra Tech project file and in long-term data package storage at a third-party professional document storage firm. Electronic data results will be maintained in a database on a password protected Structured Query Language (SQL) server.

Document	Location Maintained
Geophysical Survey Documents and Records in the Form of Survey Data: • Raw Geophysical Survey Data • Processed Geophysical Survey Data • Processed final format files (maps/profiles) compatible with ArcView Version 10 or specified GIS platform • Photographs (may be included in report)	Raw and processed data and final maps will be stored on CD in the Tetra Tech project files and electronically in the electronic Files. Processed final format files (maps/profiles) and the final reports will be uploaded to NIRIS. Processed final format files (maps) compatible with ArcView Version 10 or specified GIS platform will be maintained in the Tetra Tech GIS server.
Other Documents: • HASP • All letter and e-mail correspondence with regulatory agencies, including approvals and comments • Telephone logs • Field investigation data packages • Data Validation Memoranda (includes tabulated data summary forms) • All versions of project reports • RI Report NAS Brunswick Site 12	Tetra Tech project file; final reports will be uploaded to NIRIS. All versions of the reports and all support documents (e.g., Data Validation Reports) will be stored in hardcopy in the Tetra Tech project file and electronically in the server library.

Data Handling and Management - After the RI is completed, the field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after the completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity. The data handling procedures to be followed by Katahdin and Test America will meet the requirements of the technical specifications. The electronic data results will be automatically downloaded into the Tetra Tech database in accordance with proprietary Tetra Tech processes.

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

- **Data Tracking**. Data are tracked from generation to archiving in the Tetra Tech project-specific files. The Tetra Tech Project Chemist (or designee) is responsible for tracking the samples collected and shipped to Katahdin. Upon receipt of the data packages from Katahdin and

Test America, the Tetra Tech Project Chemist will oversee the data validation effort, which includes verifying that the data packages are complete and that results for all samples have been delivered by Katahdin and Test America.

- **Data Storage, Archiving, and Retrieval**. The data packages received from Katahdin and Test America are tracked in the data validation logbook. After the data are validated, the data packages are entered into the Tetra Tech Navy CLEAN file system and archived in secure files. The field records including field logbooks, sample log sheets, chain-of-custody records, and field calibration logs will be submitted by the Tetra Tech FOL to be entered into the Navy CLEAN file system prior to archiving in secure project files. The project files are audited for accuracy and completeness. At the completion of the Navy contract, the records will be stored by Tetra Tech.

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

- **Data Reporting.** Data will be generated by the laboratory in a CLP-like format. Upon completion of data validation Tetra Tech will convert relevant data into the MEDEP EDD format and submit to MEDEP.

SAP Worksheet #30 -- Analytical Services Table

(UFP-QAPP Manual Section 3.5.2.3)

Matrix	**Analytical Group**	**Sample Location/ ID Number**	**Analytical Method**	**Data Package Turnaround Time**	**Laboratory/ Organization** (name and address, contact person and telephone number)	**Backup Laboratory/ Organization** (name and address, contact person and telephone number)
Soil, sediment , groundwater and aqueous QC samples	VOCs (minus EDB)	See Worksheet # 18	SW-846 5030, 8260B	21 Calendar days	Katahdin Analytical Services, Inc. 600 Technology Way Scarborough, Maine 04074 Contact: Jennifer Obrin Laboratory PM 207.874.2400	NA
	EDB (groundwater only)		EPA 504.1			
	Metals (total)		SW-846 6020A, 7470A			
	SVOCs (including low-level PAHs and 1,4-dioxane)		SW-846 8270D/8270D SIM			
	Explosives plus Nitroglycerin		SW-846 8330B			
	VPH		MADEP-VPH-04-1.1			
	EPH		MADEP-EPH-04-1.1			
Soil and Sediment	Explosives (sample preparation, grinding only)	See Worksheet # 18	SW-846 8330B Appendix A	Extraction within 14 calendar days	ALS Middletown 34 Dogwood Lane Middletown, Pennsylvania 17057 Contact: Denise Brooks Laboratory PM 717.944.5541	NA
Groundwater, and Aqueous QC Samples	Perchlorate	See Worksheet #18	SW-846 6850	21 calendar days	TestAmerica Laboratories 30 Community Drive, Suite 11 South Burlington, VT 05403 Contact: Jim Madison 802-923-1028 Jim.Madison@TestAmerican.com	NA

Katahdin will also perform IDW sample analysis.

SAP Worksheet #31 -- Planned Project Assessments Table

(UFP-QAPP Manual Section 4.1.1)

Assessment Type	**Frequency**	**Internal or External**	**Organization Performing Assessment**	**Person(s) Responsible for Performing Assessment** (title and organizational affiliation)	**Person(s) Responsible for Responding to Assessment Findings** (title and organizational affiliation)	**Person(s) Responsible for Identifying and Implementing Corrective Actions** (title and organizational affiliation)	**Person(s) Responsible for Monitoring Effectiveness of Corrective Action** (title and organizational affiliation)
Laboratory Systems Audit[1]	Every 2 years	External	DoD ELAP Accrediting Body	DoD ELAP Accrediting Body Auditor	Laboratory QA Manager or Laboratory Manager, Katahdin Laboratory QAM or Laboratory Manager, TestAmerica	Laboratory QA Manager or Laboratory Manager, Katahdin Laboratory QAM or Laboratory Manager, TestAmerica	Laboratory QA Manager or Laboratory Manager, Katahdin Laboratory QAM or Laboratory Manager, TestAmerica

1 Katahdin and Test America is DoD ELAP accredited and Maine accredited for all respective analytical groups (as described above) and target analytes required for this project, with the exception of the laboratory grinding procedure for SW-846 Method 8330B, which will be subcontracted to ALS. ALS is DoD ELAP accredited for this procedure. ALS will be preparing (grinding) explosives ISM samples via SW-846 8330B Appendix A, and Katahdin will extract and analyze all samples, except perchlorate, which will be extracted and analyzed by TestAmerica. The DoD ELAP and Maine accreditation documentation is included in Appendix C.

SAP Worksheet #32 -- Assessment Findings and Corrective Action Responses

(UFP-QAPP Manual Section 4.1.2)

Assessment Type	**Nature of Deficiencies Documentation**	**Individual(s) Notified of Findings** (name, title, organization)	**Timeframe of Notification**	**Nature of CA Response Documentation**	**Individual(s) Receiving CA Response** (name, title, organization)	**Time Frame for Response**
Laboratory Systems Audit	Written audit report	Leslie Diamond, Laboratory QA Manager, Katahdin	Specified by DoD ELAP Accrediting Body	Letter	DoD ELAP Accrediting Body	Specified by DoD ELAP Accrediting Body
Laboratory Systems Audit	Written audit report	Kirstin Daigle, Laboratory QAM, Test America Burlington	Specified by DOD ELAP Accrediting Body	Letter	DOD ELAP Accrediting Body	Specified by DOD ELAP Accrediting Body

SAP Worksheet #33 -- QA Management Reports Table

(UFP QAPP Manual Section 4.2)

Type of Report	**Frequency** (daily, weekly monthly, quarterly, annually, etc.)	**Projected Delivery Date(s)**	**Person(s) Responsible for Report Preparation** (title and organizational affiliation)	**Report Recipient(s)** (title and organizational affiliation)
Data Validation Report	Per SDG	Within 2 weeks after receiving the data from the laboratory	Project Chemist or Data Validator, Tetra Tech	PM, Tetra Tech; project file
Major Analysis Problem Identification (Internal Memorandum)	When persistent analysis problems are detected	Immediately upon detection of problem – on the same day	QAM, Tetra Tech	PM, Tetra Tech; QAM, Tetra Tech; Program Manager, Tetra Tech; project file
Project Monthly Progress Report	Monthly for duration of the project	Monthly	PM, Tetra Tech	PM, Tetra Tech; QAM, Tetra Tech; Program Manager, Tetra Tech; Navy RPM; project file
Laboratory QA Report	When significant plan deviations result from unanticipated circumstances	Immediately upon detection of problem (on the same day)	Laboratory PM, Katahdin and TestAmerica	PM and project file, Tetra Tech

SAP Worksheet #34 -- Verification (Step I) Process Table

(UFP-QAPP Manual Section 5.2.1)

Verification Input	Description	Internal / External	Responsible for Verification (name, organization)
Chain-of-Custody Forms	The Tetra Tech FOL or designee will review and sign the chain-of-custody form to verify that all samples listed are included in the shipment to the laboratory and that the sample information is accurate. The forms will be signed by the sampler, and a copy will be retained for the project file, Tetra Tech PM, and Tetra Tech Data Validators.	Internal	Sampler and FOL, Tetra Tech
	1 - The Laboratory Sample Custodian will review the sample shipment for completeness and integrity and will sign accepting the shipment. 2 - The Tetra Tech Data Validators will check that the chain-of-custody form was signed and dated by the Tetra Tech FOL or designee relinquishing the samples and also by the Laboratory Sample Custodian receiving the samples for analyses.	External	1 - Laboratory Sample Custodian, Katahdin 2 - Data Validators, Tetra Tech
SAP Sample Tables/ Chain-of-Custody Forms	The Tetra Tech FOL or designee will review the chain-of-custody form to verify that all samples listed in the SAP have been collected. All deviations should be documented in the report.	Internal	FOL or designee, Tetra Tech
Sample Log Sheets	Verify that information recorded in the log sheets is accurate and complete.	Internal	FOL or designee, Tetra Tech
SAP/Field Logs/ Analytical Data Packages	Ensure that all sampling SOPs were followed. Verify that deviations have been documented and MPCs have been achieved. Particular attention should be given to verify that samples were correctly identified, that sampling location coordinates are accurate, and that documentation establishes an unbroken trail of documented chain of custody from sample collection to report generation. Verify that the correct sampling and analytical methods/SOPs were applied. Verify that the sampling plan was implemented and carried out as written and that any deviations are documented.	Internal	PM or designee, Tetra Tech
SAP/Analytical SOPs/ Analytical Data Packages	Ensure that all laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied.	Internal	Laboratory QAM, Katahdin
SAP/Laboratory SOPs/ Raw Data/Applicable Control Limits Tables	Establish that all method QC samples were analyzed and in control as listed in the analytical SOPs. If method QA is not in control, the Laboratory QAM will contact the Tetra Tech PM verbally or via e-mail for guidance prior to report preparation.	Internal	Laboratory QAM, Katahdin

Verification Input	Description	Internal / External	Responsible for Verification (name, organization)
SAP/Chain-of-Custody Forms	Check that field QC samples listed in Worksheet #20 were collected as required.	Internal	FOL or designee, Tetra Tech
Electronic Data Deliverables/Analytical Data Packages	Each EDD will be verified against the chain-of-custody form and hard copy data package for accuracy and completeness. Laboratory analytical results will be verified and compared to the electronic analytical results for accuracy. Sample results will be evaluated for laboratory contamination and will be qualified for false positives using the laboratory method/preparation blank summaries. Positive results reported between the DL and the LOQ will be qualified as estimated. Extraneous laboratory qualifiers will be removed from the validation qualifier.	External	Data Validators, Tetra Tech
Analytical Data Packages	All analytical data packages will be verified internally for completeness by the laboratory performing the work. The Laboratory QAM will sign the case narrative for each data package.	Internal	Laboratory QAM, Katahdin and TestAmerica
	Each data package will be verified for completeness by the Tetra Tech Data Validator. Missing information will be requested by the Tetra Tech Data Validator from the Laboratory PM.	External	Data Validators, Tetra Tech
ISM	RSD for Field Replicates should be <50% for ISM samples	Internal	PM or designee, Tetra Tech

Verification includes field data verification and laboratory data verification. Verification inputs as per Worksheet #34 will be checked.

SAP Worksheet #35 -- Validation (Steps IIa and IIb) Process Table

(UFP-QAPP Manual Section 5.2.2) (Figure 37 UFP-QAPP Manual) (Table 9 UFP-QAPP Manual)

Step IIa/ IIb	Validation Input	Description	Responsible for Validation (name, organization)
IIa	SA/Sample Log Sheets	Ensure that sample locations are correct and in accordance with the SAP proposed locations. Document any discrepancies in the final report.	PM, FOL, or designee, Tetra Tech
IIa	Chain-of-Custody Forms	Ensure that the custody and integrity of the samples was maintained from collection to analysis and that the custody records are complete and any deviations are recorded. Review that the samples were shipped and store at the required temperature and that the sample pH values for chemically preserved samples meet the requirements listed in Worksheet #19. Ensure that the analyses were performed within the holding times listed in Worksheet #19.	Project Chemist or Data Validators, Tetra Tech
IIa/IIb	SAP/Laboratory Data Packages/ EDDs	Ensure that the laboratory QC samples listed in Worksheet #28 were analyzed and that the MPCs listed in Worksheet #12 were met for all field samples and QC analyses. Check that specified field QC samples were collected and analyzed and that the analytical QC criteria set up for this project were met.	Project Chemist or Data Validators, Tetra Tech
		Check the field sampling precision by calculating the RPD for field duplicate samples. Check the laboratory precision by reviewing the RPD or %D values from laboratory duplicate analyses, MS/MSDs, and LCS/LCSD, if available. Ensure compliance with the methods and project MPCs accuracy goals listed in Worksheet #12.	
		Check that the laboratory recorded the temperature at sample receipt and the pH of chemically preserved samples to ensure sample integrity from sample collection to analysis.	
		Review the chain-of-custody forms generated in the field to ensure that the required analytical samples have been collected, appropriate sample identifications have been used, and correct analytical methods have been applied. The Tetra Tech Data Validator will verify that elements of the data package required for validation are present, and if not, the laboratory will be contacted and the missing information will be requested. Validation will be performed as per Worksheet #36. Check that all data have been transferred correctly and completely to the final SQL database.	

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

SAP Worksheet #36 -- Analytical Data Validation (Steps IIa and IIb) Summary Table

(UFP-QAPP Manual Section 5.2.2.1)

Step IIa/IIb	Matrix	Analytical Group	Validation Criteria	Data Validator (title and organizational affiliation)
IIa and IIb	Soil, sediment, groundwater, and aqueous QC samples	VOCs, SVOCs including low-level PAHs plus 1,4-dioxane, VPH, and EPH	Tier II[1] data validation. Project-specific criteria for VOCs by SW-846 8260B, SVOCs by SW-846 8270D, low-level PAHs and 1,4-dioxane by SW-846 8270D SIM, VPH by MADEP-VPH-04-1.1, and EPH by MADEP-EPH-04-1.1 are listed in Worksheet #s 12, 15, 24, and 28. Region I USEPA-Northeast (NE) Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part II, December 1996 (USEPA, 1996) will be applied using these criteria.	Tetra Tech, Data Validation Chemist
IIa and IIb	Soil, sediment, groundwater, and aqueous QC samples	EDB, Explosives plus Nitroglycerin, Pesticides, and PCBs	Tier II[1] data validation. Criteria for EDB by SW-846 8011 are listed in Worksheet #s 12, 15, 19, 24, and 28. Region I USEPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part III, February 2004 (USEPA, 2004) will be applied using these criteria.	
IIa and IIb	Soil, sediment, groundwater, and aqueous QC samples	Metals	Tier II[1] data validation. Project-specific criteria for metals by SW-846 6010C/6020A/7470A/7471B are listed in Worksheets #12, #15, #19, #24, and #28. Region I USEPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part IV, November 2008 (USEPA, 2008) will be applied using these criteria.	
IIa and IIb	Groundwater and Aqueous QC Samples	Perchlorate	Tier II[1] data validation. Project-specific criteria for perchlorate by SW-846 6850 are listed in Worksheets #12, #15, #19, #24, and #28.	Data Validation Specialist, Tetra Tech

1 – As defined in the Region I EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part I, Attachment B, “Region 1 Tiered Organic and Inorganic Data Validation Guidelines”, July 1, 1993, Draft (USEPA, 1996).

SAP Worksheet #37 -- Usability Assessment

(UFP-QAPP Manual Section 5.2.3)

Data Usability Assessment
The usability of the data generated during the RI directly affects whether project objectives can be achieved. The following characteristics will be evaluated at a minimum, and the results of these evaluations will be included in the project report. The characteristics will be evaluated for multiple concentration levels if the evaluator determines that this is necessary. To the extent required by the type of data being reviewed, the evaluator will consult with other technically competent individuals to render sound technical assessments of these DQI characteristics: • **Completeness** For each matrix scheduled to be sampled, the Tetra Tech FOL, acting on behalf of the Project Team, will prepare a table listing to compare planned samples/analyses to collected samples/analyses. If deviations from the scheduled sample collection or analyses are identified, the Tetra Tech PM and Project Risk Assessor will determine whether the deviations compromise the ability to meet project objectives. If they do, the Tetra Tech PM will consult with the Navy RPM and other Project Team members, as necessary (determined by the Navy RPM), to develop appropriate corrective actions. • **Precision** The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether precision goals for field duplicates and laboratory duplicates were met. This will be accomplished by comparing duplicate results to precision goals identified in Worksheet #s 12 and 28. This will also include a comparison of field and laboratory precision with the expectation that field duplicate results will be no less precise than laboratory duplicate results. If the goals are not met, or if data have been flagged as estimated (J qualifier), limitations on the use of the data will be described in the project report. **Accuracy** The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether the accuracy/bias goals were met for project data. This will be accomplished by comparing %Rs of LCS, LCSD, MS, MSD, and surrogate compounds to accuracy goals identified in Worksheet #28. This assessment will include an evaluation of field and laboratory contamination; instrument calibration variability; and analyte recoveries for surrogates, MSs, and LCSs. If the goals are not met, limitations on the use of the data will be described in the project report. Bias of the qualified results and a description of the impact of identified non-compliances on a specific data package or on the overall project data will also be described in the project report. • **Representativeness** A Tetra Tech Project Scientist, identified by the Tetra Tech PM and acting on behalf of the Project Team, will determine whether the data are adequately representative of intended populations, both spatially and temporally. This will be accomplished by verifying that samples were collected and processed for analysis in accordance with the SAP, by reviewing spatial and temporal data variations, and by comparing these characteristics to expectations. The usability report will describe the representativeness of the data for each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the Project Scientist indicates that a quantitative analysis is required. • **Comparability** The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether the data generated under this project are sufficiently comparable to historical site data generated by different methods and for samples collected using different procedures and under different site conditions. This will be accomplished by comparing overall precision and bias among data sets for

each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the Tetra Tech Project Chemist indicates that such quantitative analysis is required.

- **Sensitivity**
  The Tetra Tech Project Chemist, acting on behalf of the Project Team, will determine whether project sensitivity goals listed in Worksheet #15 were achieved. The overall sensitivity and LOQs from multiple data sets for each matrix and analysis will be compared. If sensitivity goals are not achieved, the limitations on the data will be described in the project report. The Tetra Tech Project Chemist may enlist the help of the Project Risk Assessor to evaluate deviations from planned sensitivity goals.

- **Project Assumptions and Data Outliers**
  The Tetra Tech PM and designated team members will evaluate whether project assumptions are valid. This will typically be a qualitative evaluation but may be supported by quantitative evaluations. The type of evaluation depends on the assumption being tested. Quantitative assumptions include those related to data distributions (e.g., normal or log-normal) and estimates of data variability. Potential data outliers will be removed if a review of the associated data indicates that the results have an assignable cause that renders them inconsistent with the remainder of the data. During this evaluation, the team will consider whether outliers could be indications of unanticipated site conditions.

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

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

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

Identify the personnel responsible for performing the usability assessment:

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

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

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

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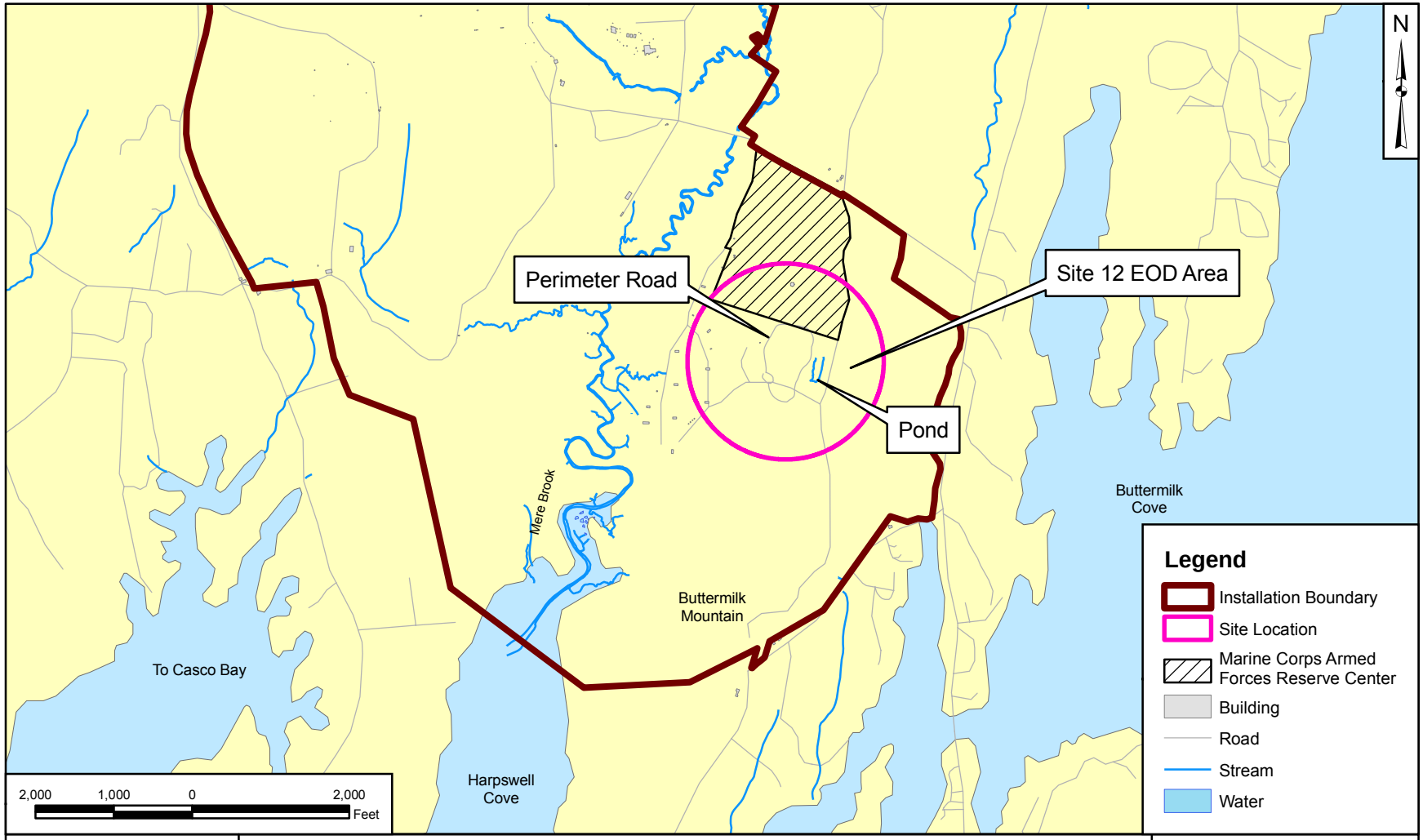

DRAWN BY S. STROZ	DATE 05/27/09	TETRA TECH	CONTRACT NUMBER CTO WE09
CHECKED BY M. COFFMAN	DATE 12/23/10	SITE LOCATION MAP SITE 12 EOD AREA NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY ___ DATE ___
COST/SCHEDULE AREA			APPROVED BY ___ DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 10-1 / REV 0

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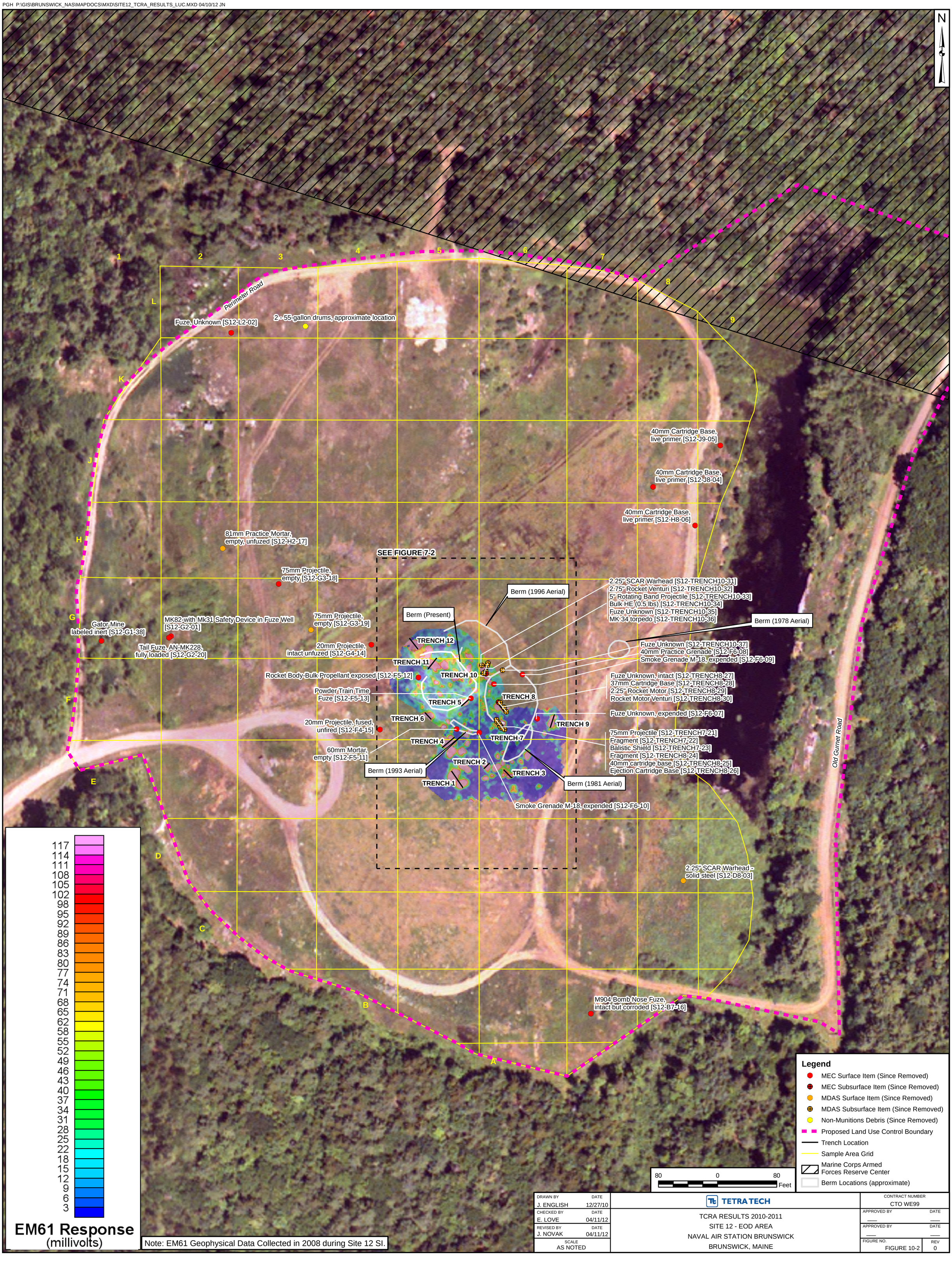

Note: EM61 Geophysical Data Collected in 2008 during Site 12 SI.

DRAWN BY J. ENGLISH	DATE 12/27/10	TETRA TECH	CONTRACT NUMBER CTO WE99
CHECKED BY E. LOVE	DATE 04/11/12	TCRA RESULTS 2010-2011 SITE 12 - EOD AREA NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY — DATE —
REVISED BY J. NOVAK	DATE 04/11/12		APPROVED BY — DATE —
SCALE AS NOTED			FIGURE NO. FIGURE 10-2 REV 0

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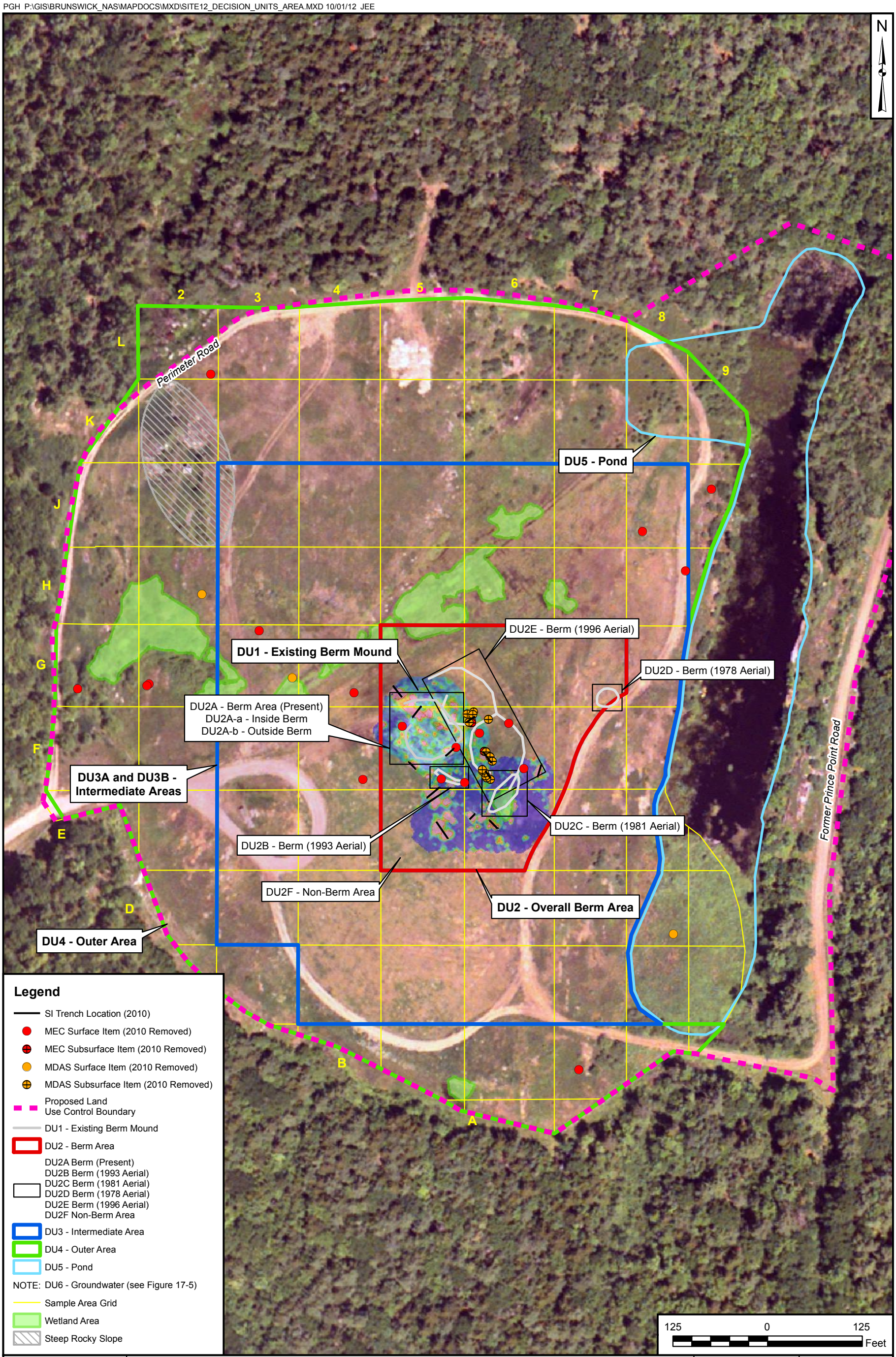
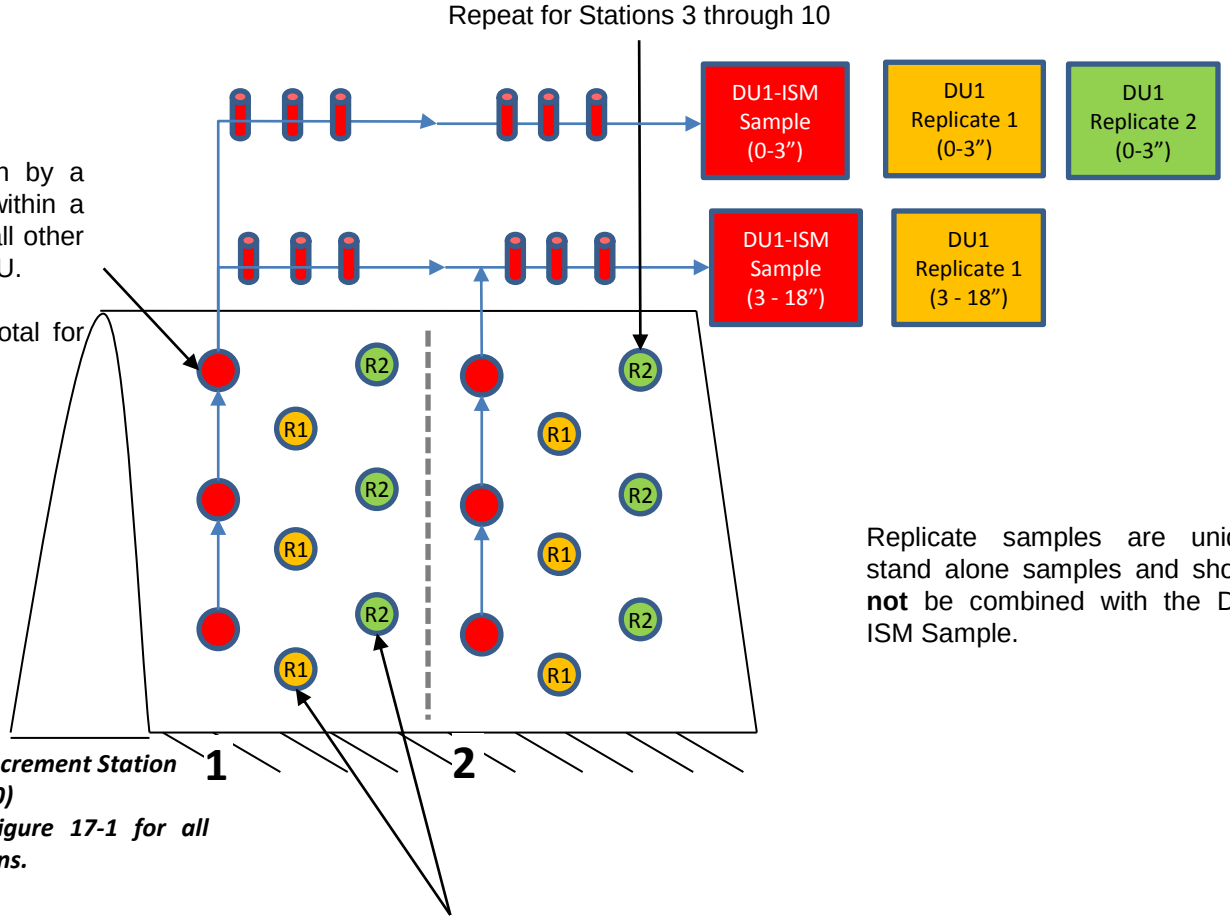


DRAWN BY J. ENGLISH — DATE 08/09/11	TETRA TECH	CONTRACT NUMBER 00645	CTO NUMBER WE09
CHECKED BY E. LOVE — DATE 10/01/12	SITE 12 EOD AREA DECISION UNITS LOCATION MAP FORMER NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY — DATE —	
REVISED BY J. ENGLISH — DATE 10/01/12		APPROVED BY — DATE —	
SCALE AS NOTED		FIGURE NO. FIGURE 11 - 1	REV 1

Figure 14-1
ISM Systematic Random Sampling and Replicate Design for DU1

DU1 Existing Berm Mound



An increment's location (shown by a red dot) will be chosen once within a sample unit, then repeated for all other increment grids/stations in the DU.

DU1 will have **30** increments total for each sample depth.

Replicate samples are unique stand alone samples and should **not** be combined with the DU1 ISM Sample.

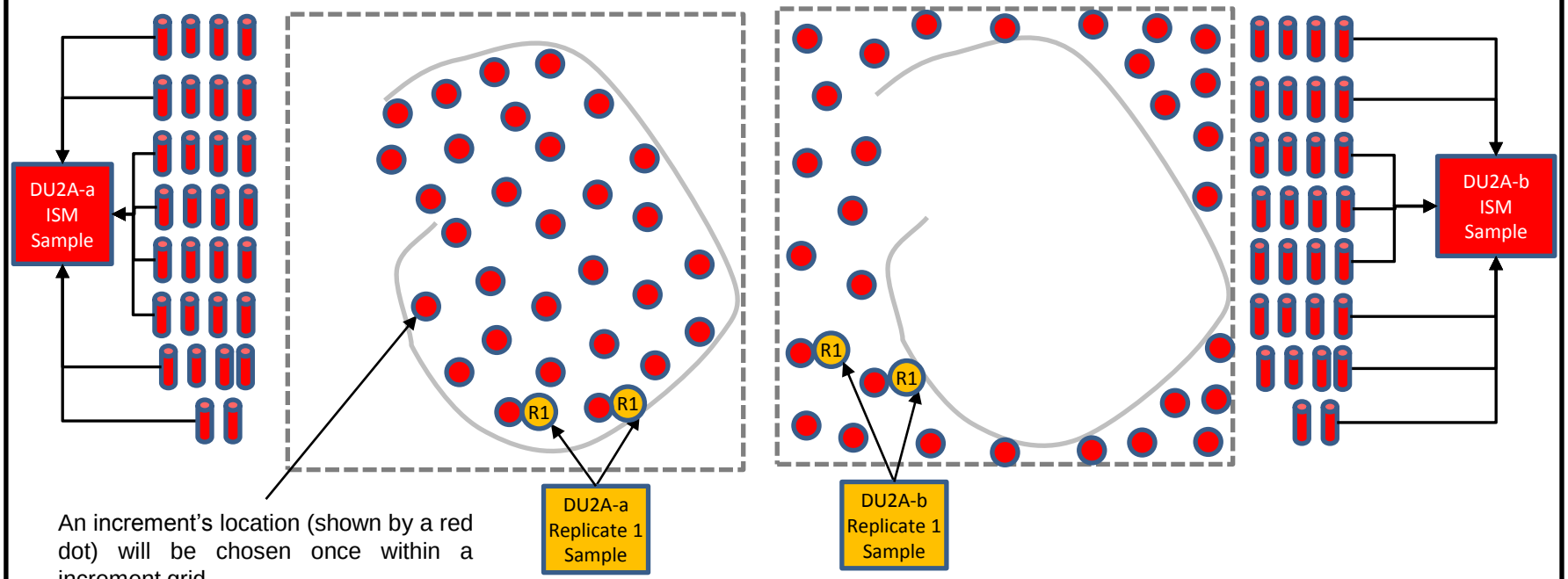
For the 0 to 3" interval two replicate subsamples (also called a triplicate) locations will be randomly chosen (shown by orange/green dots), then repeated for the other sample grids in the same ISM sampling unit.

For the 3 to 18" interval one replicate subsample will be collected. The subsurface replicate will be co-located with the first replicated for the 0 to 3" interval (orange dots).

Figure 14-2
ISM Systematic Random Sampling and Replicate Design
DU2A

DU2A-a
(Floor of berm area)

DU2A-b
(Area within DU2A boundary and outside the berm area)



An increment's location (shown by a red dot) will be chosen once within a increment grid.

DU2A-a will have **30** increments total, inside the berm.
DU2A-b will have **30** increments total, outside the berm.

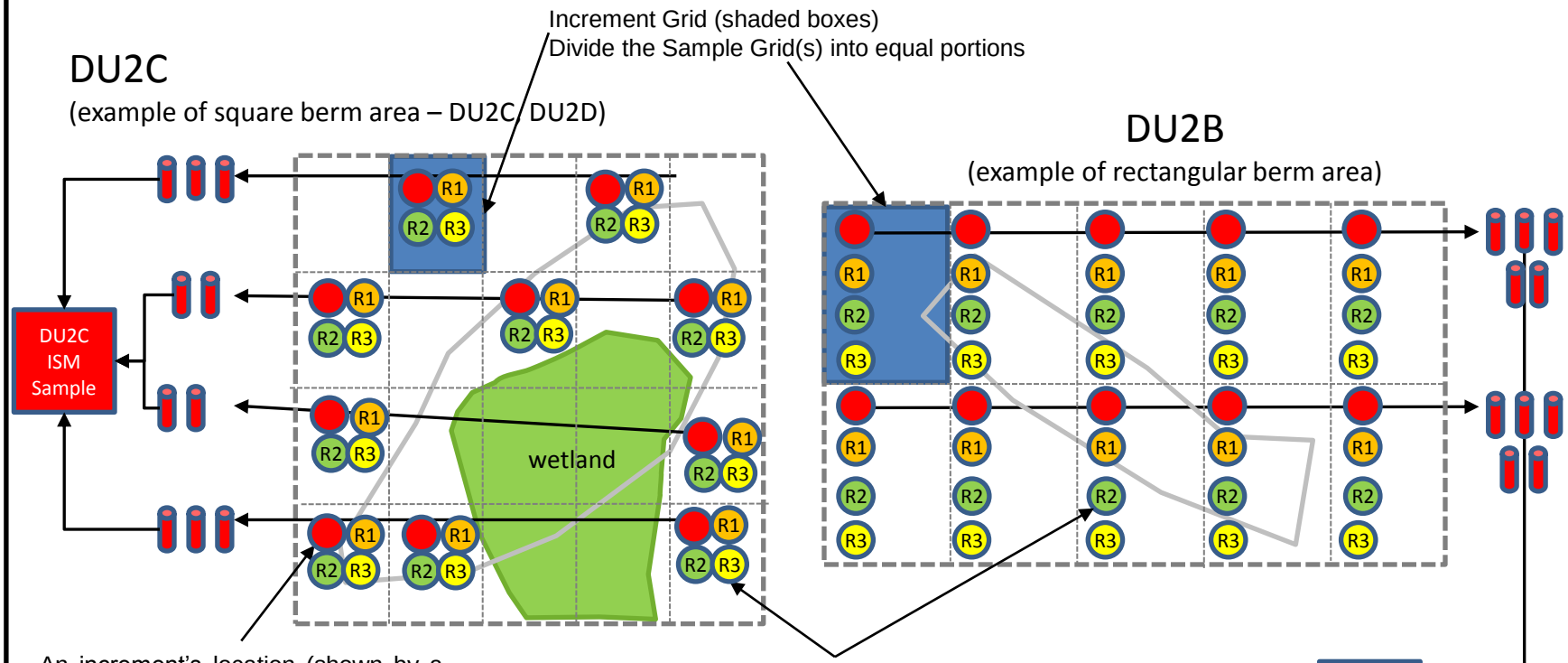
Note: ISM samples from DU2A-a and DU2A-b are individual samples and should **not** be combined.

Replicate samples are unique stand alone samples and should **not** be combined with the ISM Sample.

Replicate increment locations will be spaced approximately 2 feet from the ISM increment or neighboring increment using the typical orange dots shown for **EACH** increment sample. These patterns should be repeated for every ISM increment location (red dot) for DU2A-a and DU2A-b.

DU2A-a and DU2A-b have one replicate each.

Figure 14-3
ISM Systematic Random Sampling and Replicate Design
DU2B through DU2D



An increment's location (shown by a red dot) will be chosen once within a increment grid, then repeated for all other increment grids in the DU.

DU2B, DU2C, and DU2D will have **10** increments total, each.

Replicate samples are unique stand alone samples and should **not** be combined with the ISM Sample.

Replicate increment locations will be spaced approximately 2 feet from the ISM increment or neighboring increment using the pattern of orange, green, and yellow dots shown. These patterns should be repeated for every ISM increment location (red dot) for DU2B through DU2D, based on the shape of the berm area. DU2B, C, and D have three replicates each.

DU2B Replicate 1 Sample

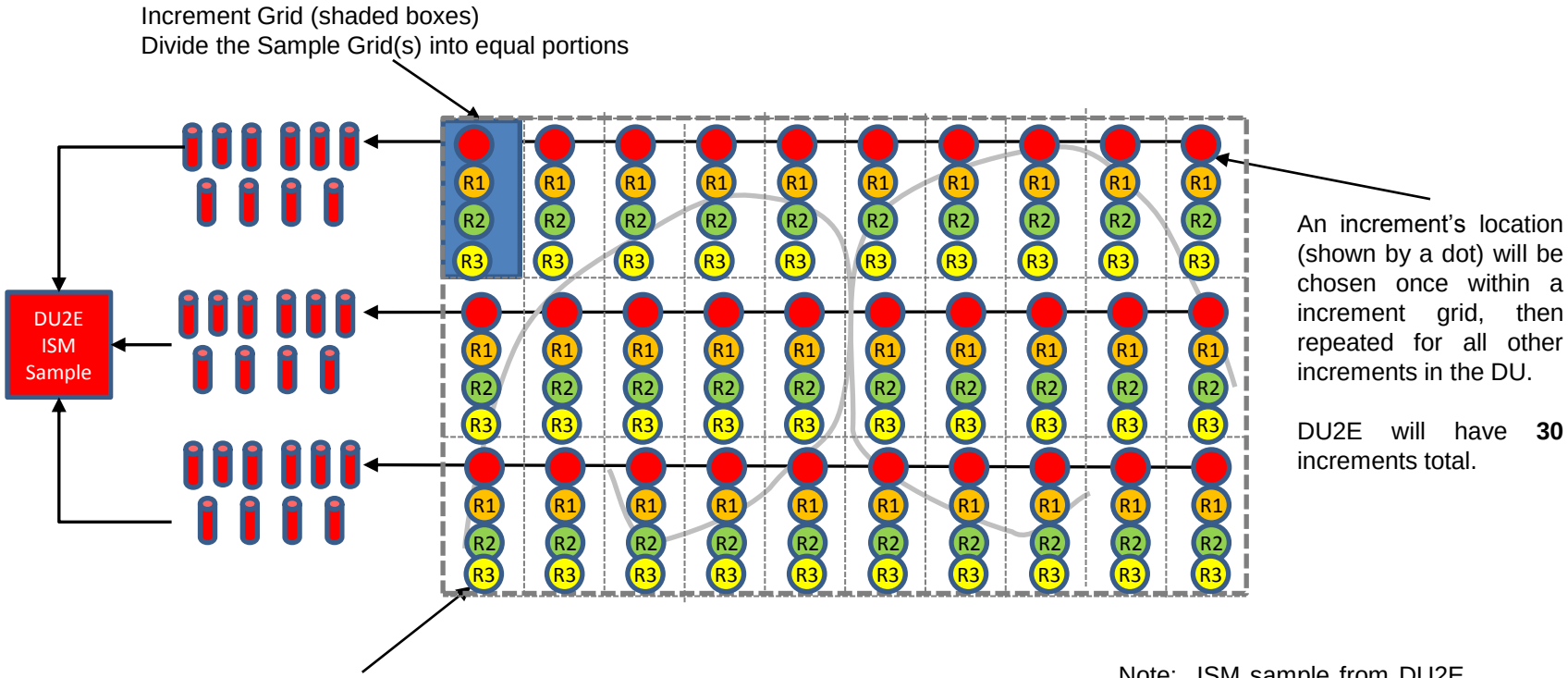
DU2B Replicate 2 Sample

DU2B Replicate 3 Sample

DU2B ISM Sample

Note: ISM samples from DU2B, DU2C, and DU2D are individual samples and should **not** be combined.

Figure 14-4
ISM Systematic Random Sampling and Replicate Design
DU2E



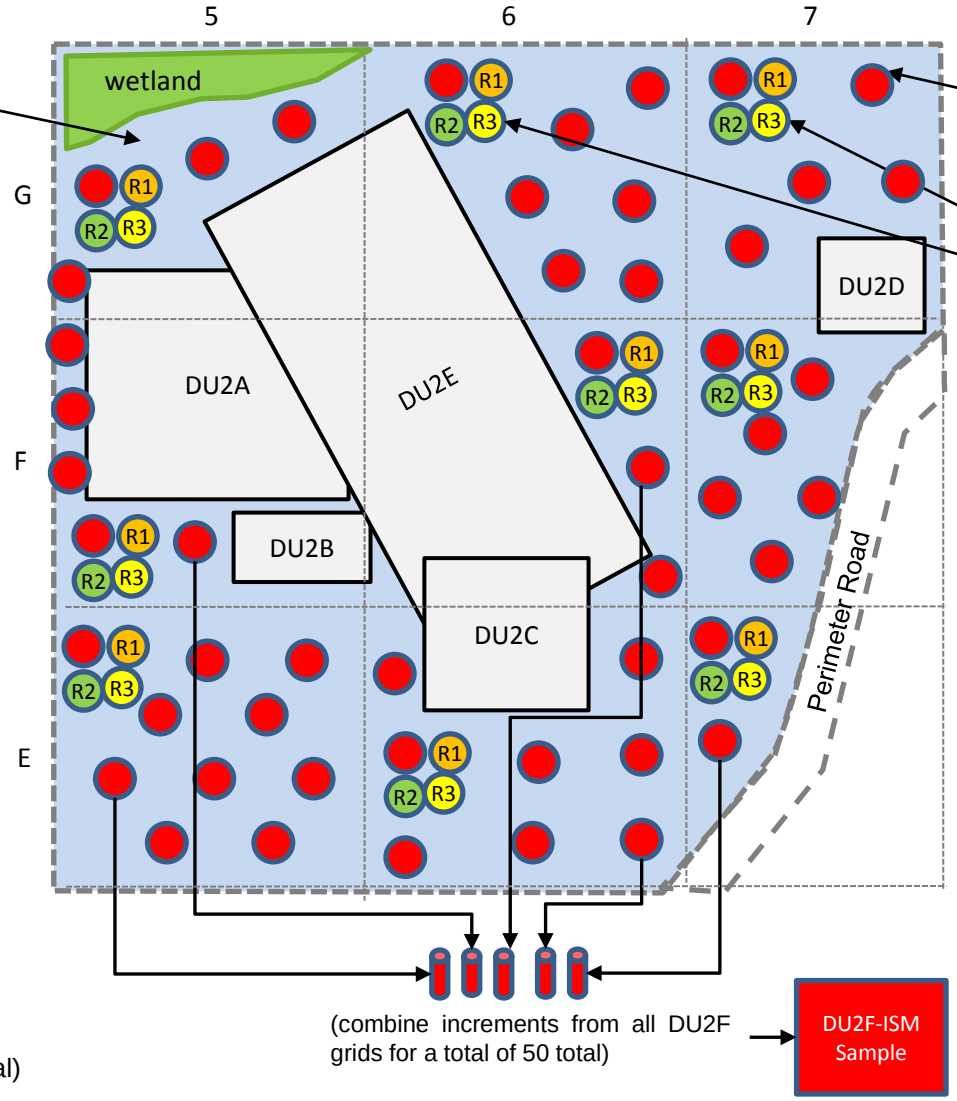
Replicate increment locations will be spaced approximately 2 feet from the ISM increment or neighboring increment using the pattern of orange, green, and yellow dots shown . This pattern should be repeated for every ISM increment location (red dot) for DU2E. DU2E has three replicates.

Note: ISM sample from DU2E is an individual sample and should **not** be combined with other subunits.

Replicate samples are unique stand alone samples and should **not** be combined with the DU2E ISM Sample.

Figure 14-5
ISM Systematic Random Sampling and Replicate Design
DU2F

Increment Grid (blue shaded area)
Divide the Sample Grid(s) into equal portions, avoiding wetlands and berm areas.



An increment's location shown by a red dot.

DU2F will have **50** increments total.

Replicate subsample locations will be approximately 2 feet from the ISM increment using the pattern of orange, green, and yellow dots shown. This pattern should be repeated for every ISM increment location (red dot) in DU2F. DU2F has three replicates.

Replicate samples are unique stand alone samples and should **not** be combined with the DU2F ISM Sample.

DU2F Replicate 1

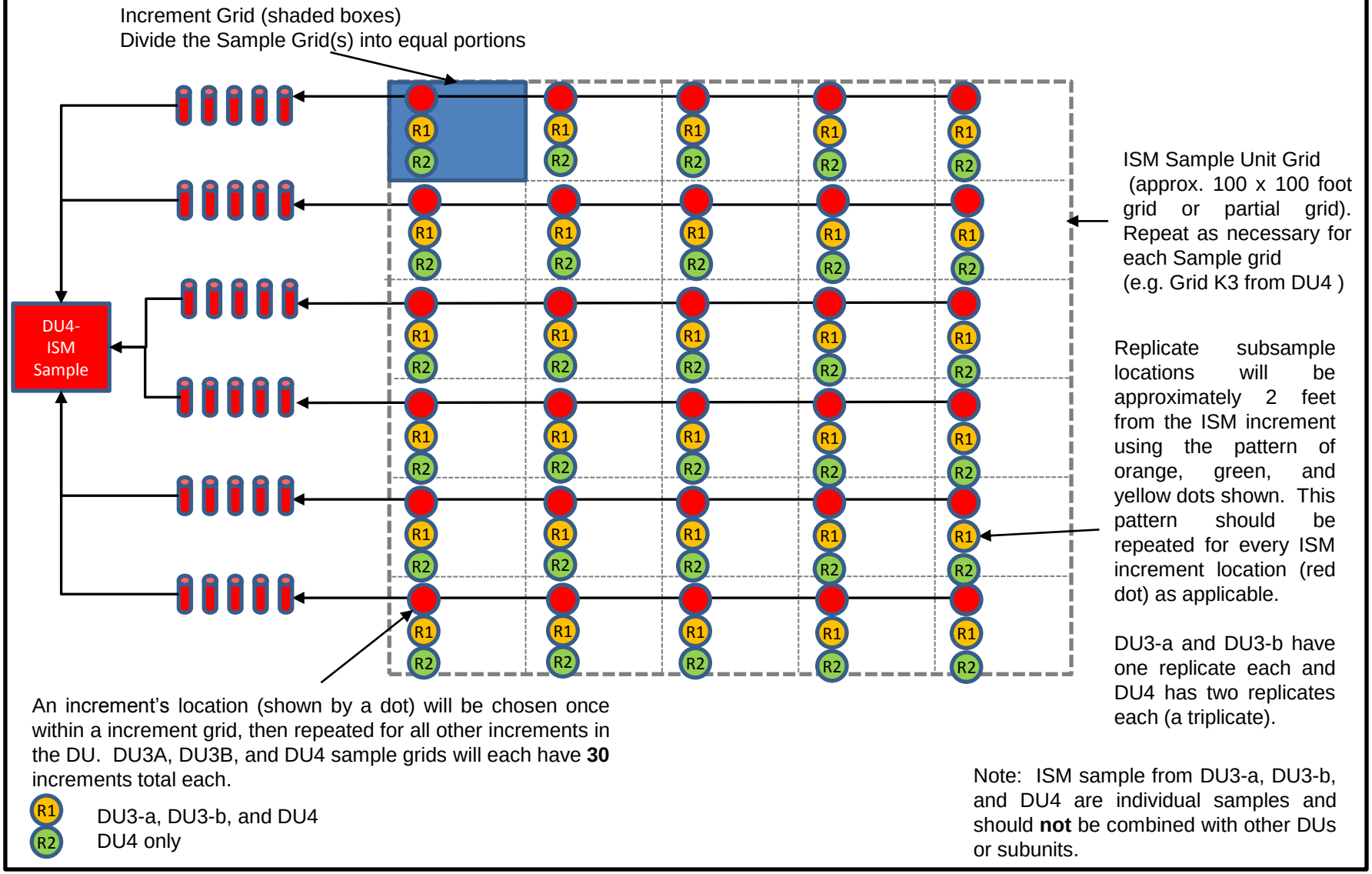
DU2F Replicate 2

DU2F Replicate 3

(Typical)

Note: ISM sample from DU2F is an individual sample and should **not** be combined with other subunits.

Figure 14-6
ISM Systematic Random Sampling and Replicate Design
DU3-a, DU3-b, and DU4



Note: ISM sample from DU3-a, DU3-b, and DU4 are individual samples and should **not** be combined with other DUs or subunits.

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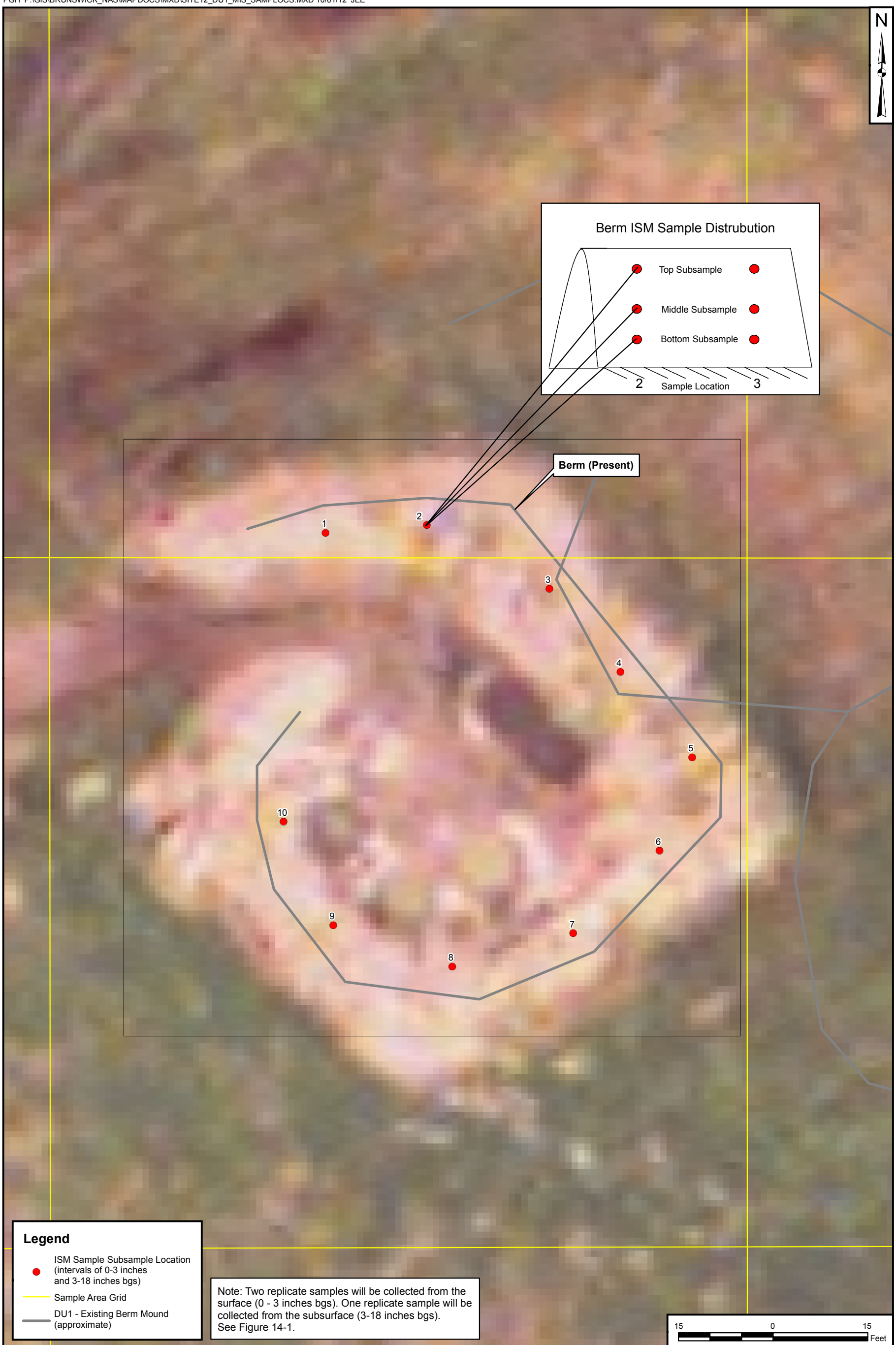

DRAWN BY J. ENGLISH DATE 08/09/11	TETRA TECH	CONTRACT NUMBER 0645	CTO NUMBER WE09
CHECKED BY E. LOVE DATE 10/01/12	SITE 12 EOD AREA DU1 (EXISTING BERM MOUND) ISM SURFACE SOIL AND ISM SUBSURFACE SOIL SAMPLE LOCATION MAP FORMER NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY ___ DATE ___	
REVISED BY J. ENGLISH DATE 10/01/12		APPROVED BY ___ DATE ___	
SCALE AS NOTED		FIGURE NO. FIGURE 17 - 1	REV 1

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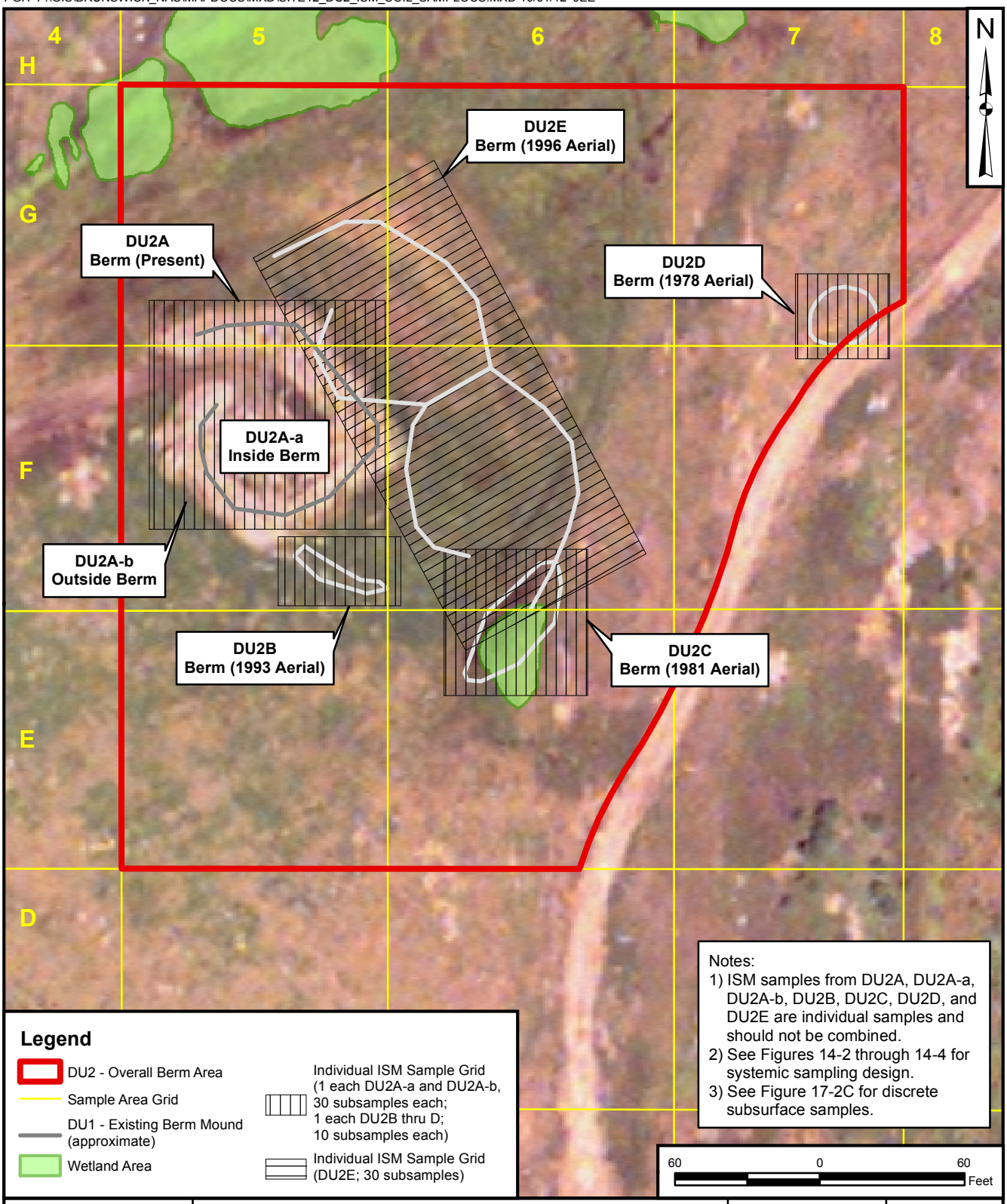

Notes:
1) ISM samples from DU2A, DU2A-a, DU2A-b, DU2B, DU2C, DU2D, and DU2E are individual samples and should not be combined.
2) See Figures 14-2 through 14-4 for systemic sampling design.
3) See Figure 17-2C for discrete subsurface samples.

DRAWN BY J. ENGLISH	DATE 08/09/11	TETRA TECH	CONTRACT NUMBER 0645	CTO NUMBER WE09
CHECKED BY E. LOVE	DATE 10/01/12	SITE 12 EOD AREA DU2A, 2B, 2C, AND 2D (LOCALIZED BERM AREAS) ISM SURFACE SOIL LOCATION MAP FORMER NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY ___	DATE ___
REVISED BY J. ENGLISH	DATE 10/01/12		APPROVED BY ___	DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 17-2A	REV 1

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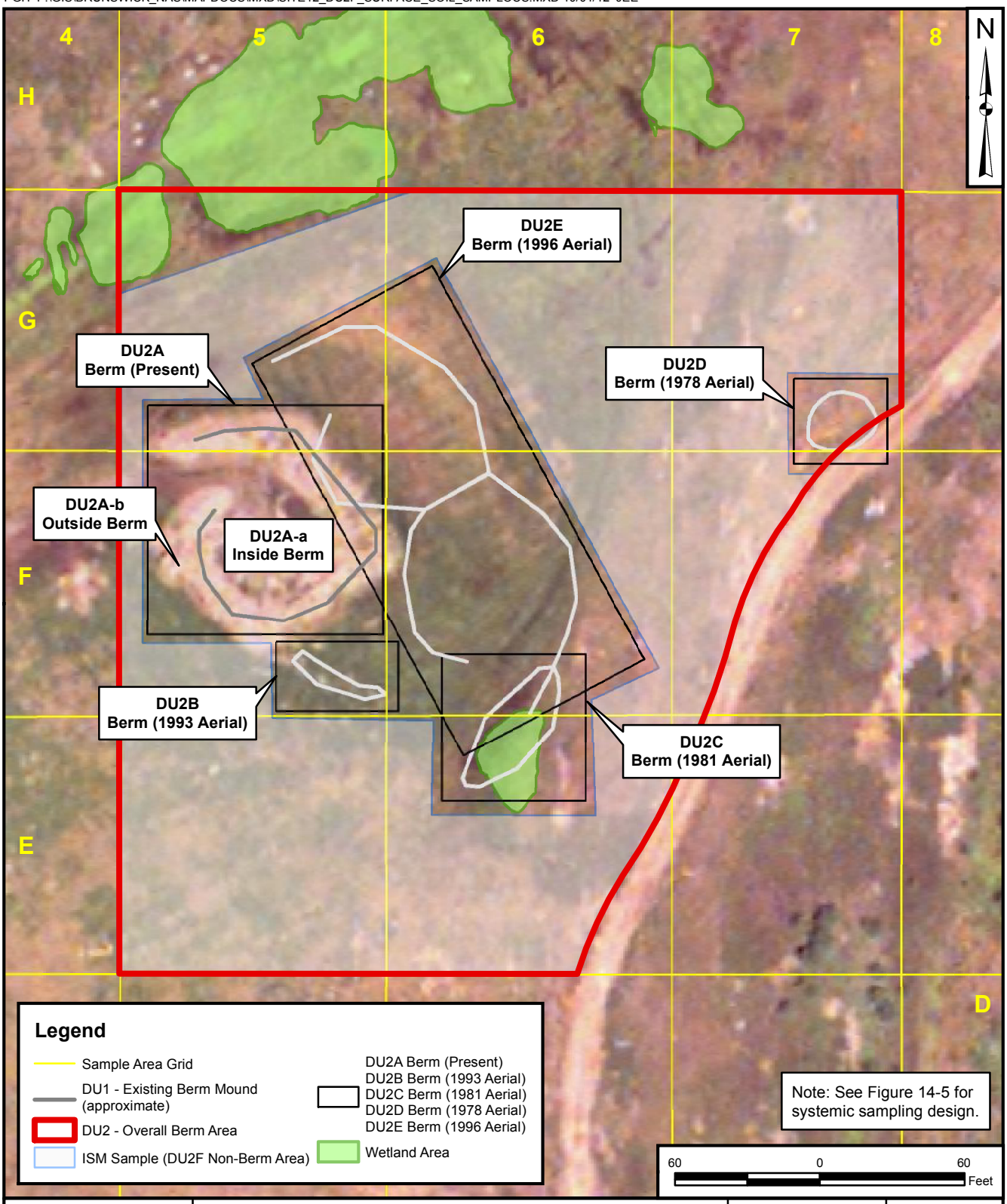
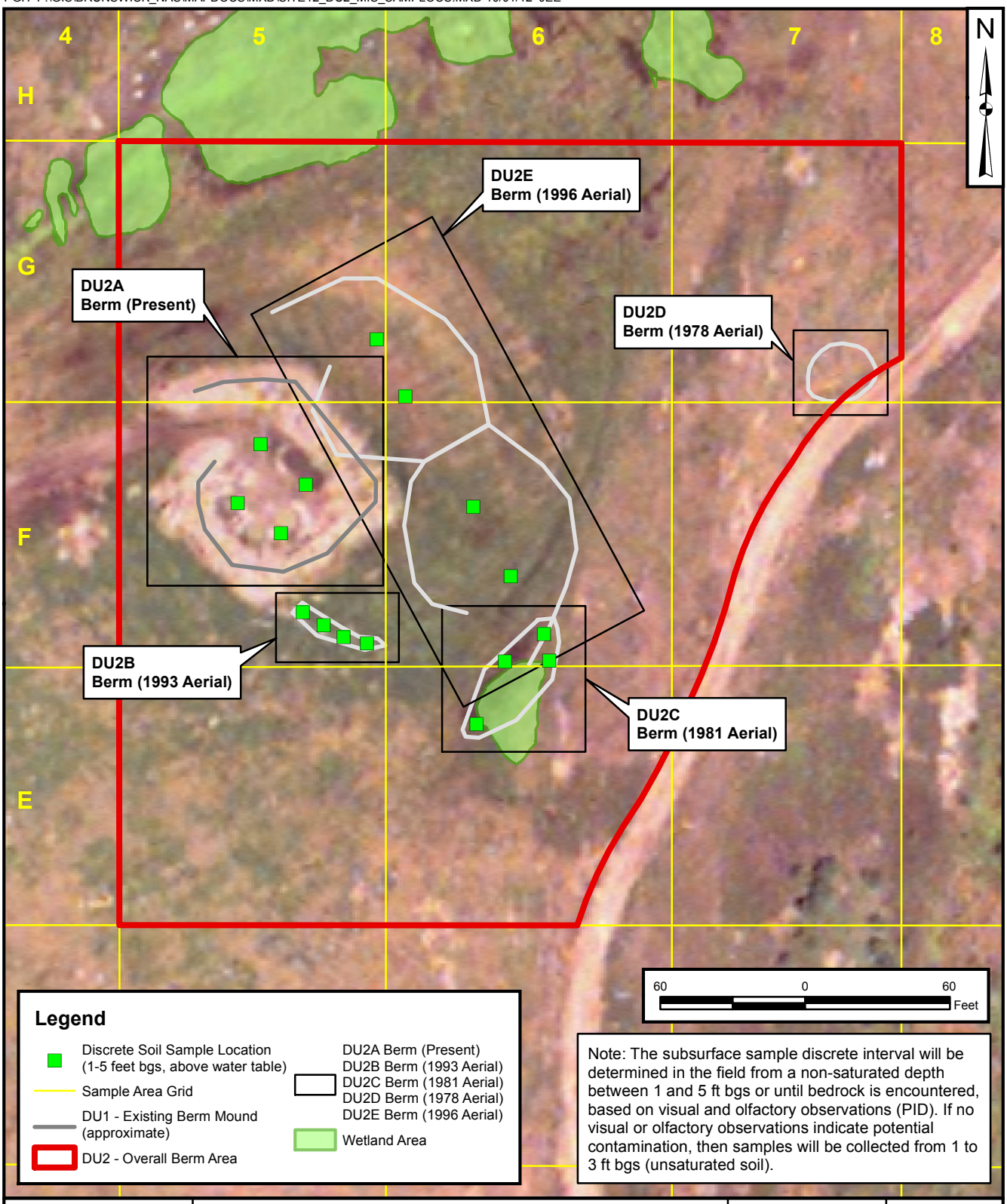


DRAWN BY J. ENGLISH	DATE 08/03/12	TETRA TECH	CONTRACT NUMBER 0645	CTO NUMBER WE09
CHECKED BY L. KLINK	DATE 10/01/12	SITE 12 EOD AREA DU2F SURFACE SOIL SAMPLE LOCATION MAP (NON-BERM AREA) FORMER NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY ___	DATE ___
REVISED BY ___	DATE ___		APPROVED BY ___	DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 17-2B	REV 1

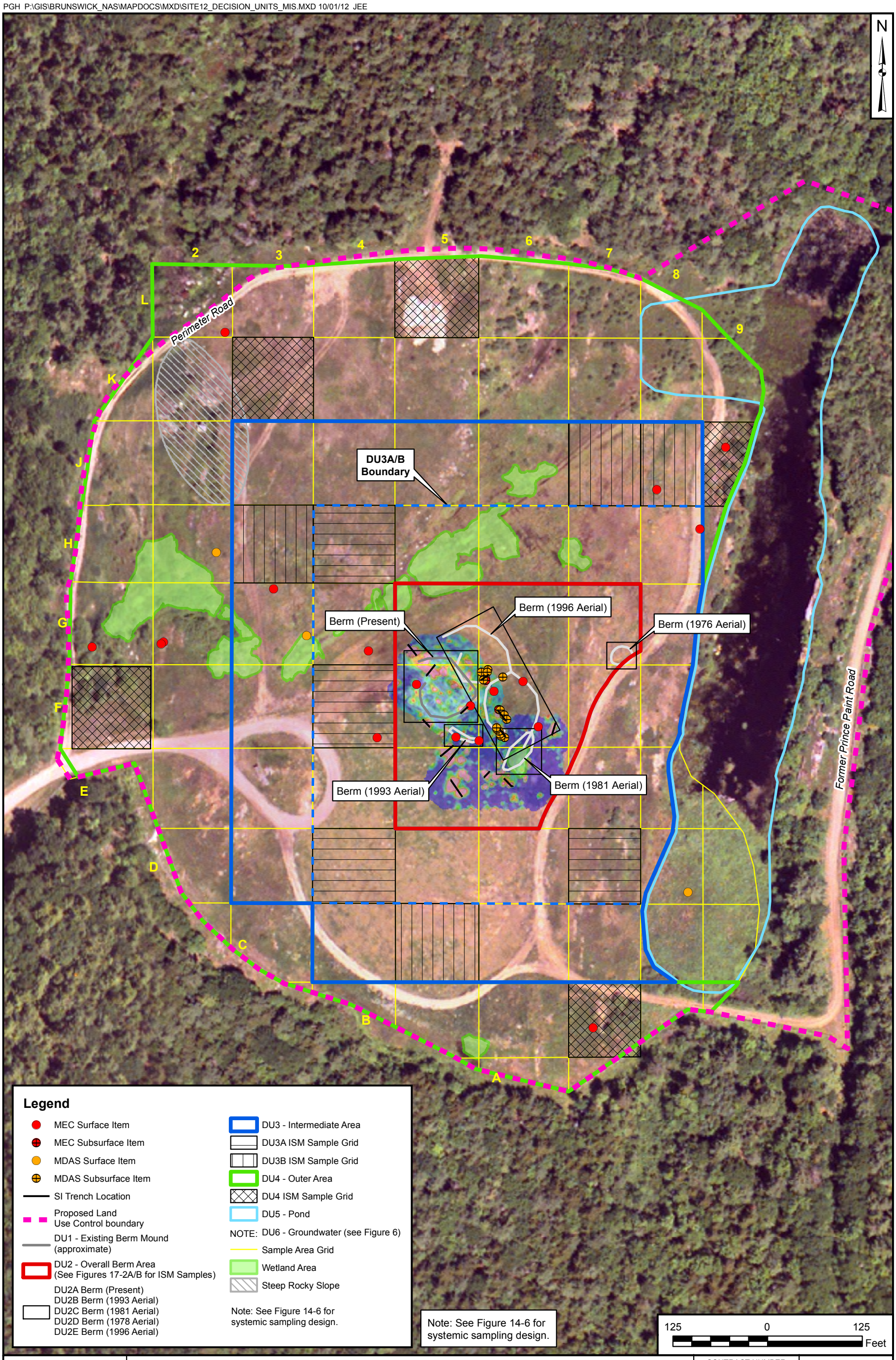
PGH P:\GIS\BRUNSWICK_NAS\MAPDOCS\MXD\SITE12_DU2_MIS_SAMPLOCS.MXD 10/01/12 JEE



Note: The subsurface sample discrete interval will be determined in the field from a non-saturated depth between 1 and 5 ft bgs or until bedrock is encountered, based on visual and olfactory observations (PID). If no visual or olfactory observations indicate potential contamination, then samples will be collected from 1 to 3 ft bgs (unsaturated soil).

DRAWN BY J. ENGLISH	DATE 08/09/11	TETRA TECH	CONTRACT NUMBER 0645	CTO NUMBER WE09
CHECKED BY E. LOVE	DATE 10/01/12	SITE 12 EOD AREA DU2A, 2B, 2C, 2D AND 2E (LOCALIZED BERM AREAS) DISCRETE SOIL SAMPLE LOCATION MAP FORMER NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY ___	DATE ___
REVISED BY J. ENGLISH	DATE 10/01/12		APPROVED BY ___	DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 17-2C	REV 1

PGH P:\GIS\BRUNSWICK_NAS\MAPDOCS\MXD\SITE12_DECISION_UNITS_MIS.MXD 10/01/12 JEE



DRAWN BY	DATE	TETRA TECH	CONTRACT NUMBER	CTO NUMBER
J. ENGLISH	08/09/11		0645	WE09
CHECKED BY	DATE	SITE 12 EOD AREA DU3A (INTERMEDIATE AREA - INNER), DU3B (INTERMEDIATE AREA - OUTER), AND DU4 (OUTER AREA) ISM SURFACE SOIL SAMPLE LOCATION MAP FORMER NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY	DATE
E. LOVE	10/01/12		—	—
REVISED BY	DATE		APPROVED BY	DATE
J. ENGLISH	10/01/12		—	—
SCALE			FIGURE NO.	REV
AS NOTED			FIGURE 17 - 3	1

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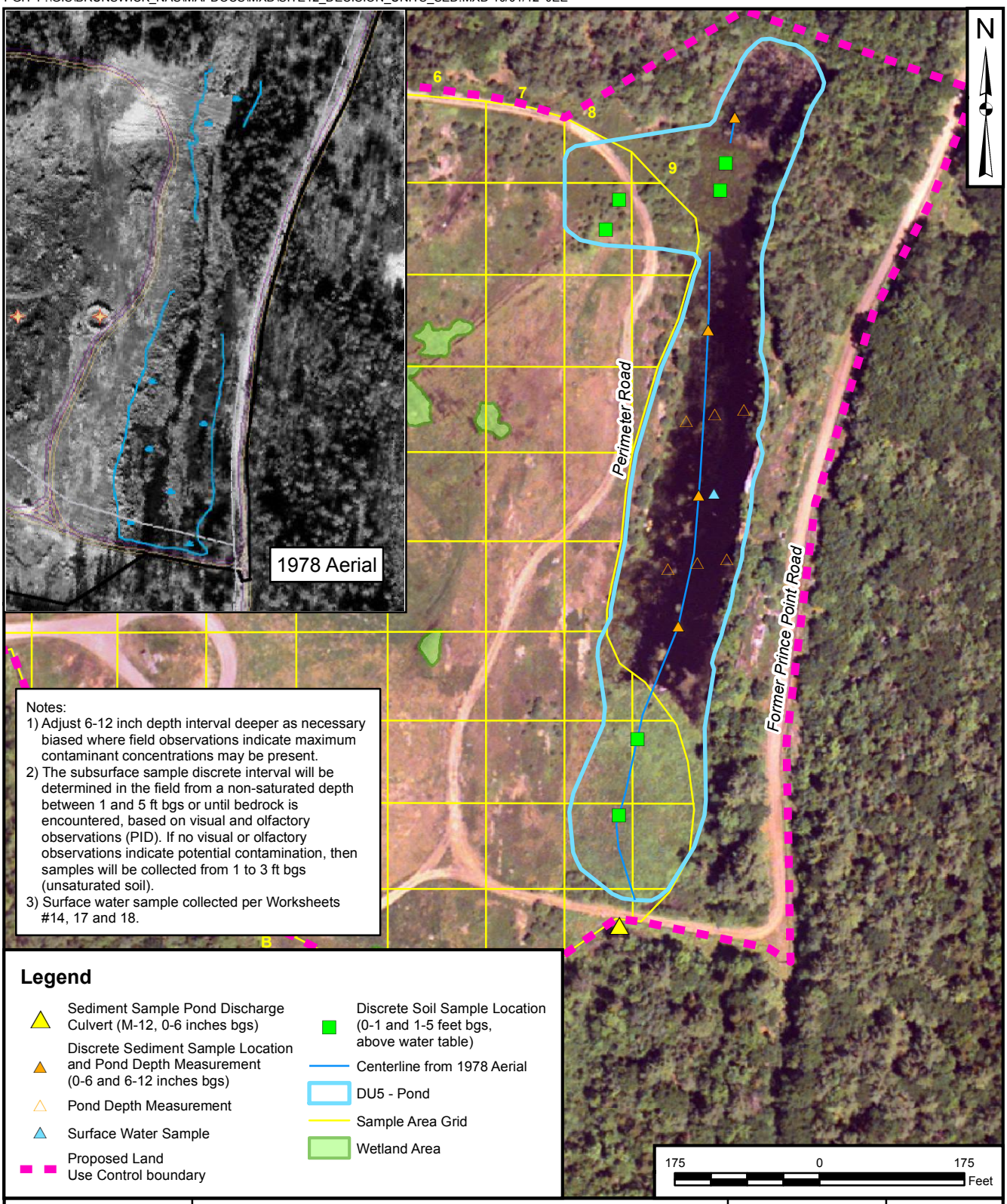
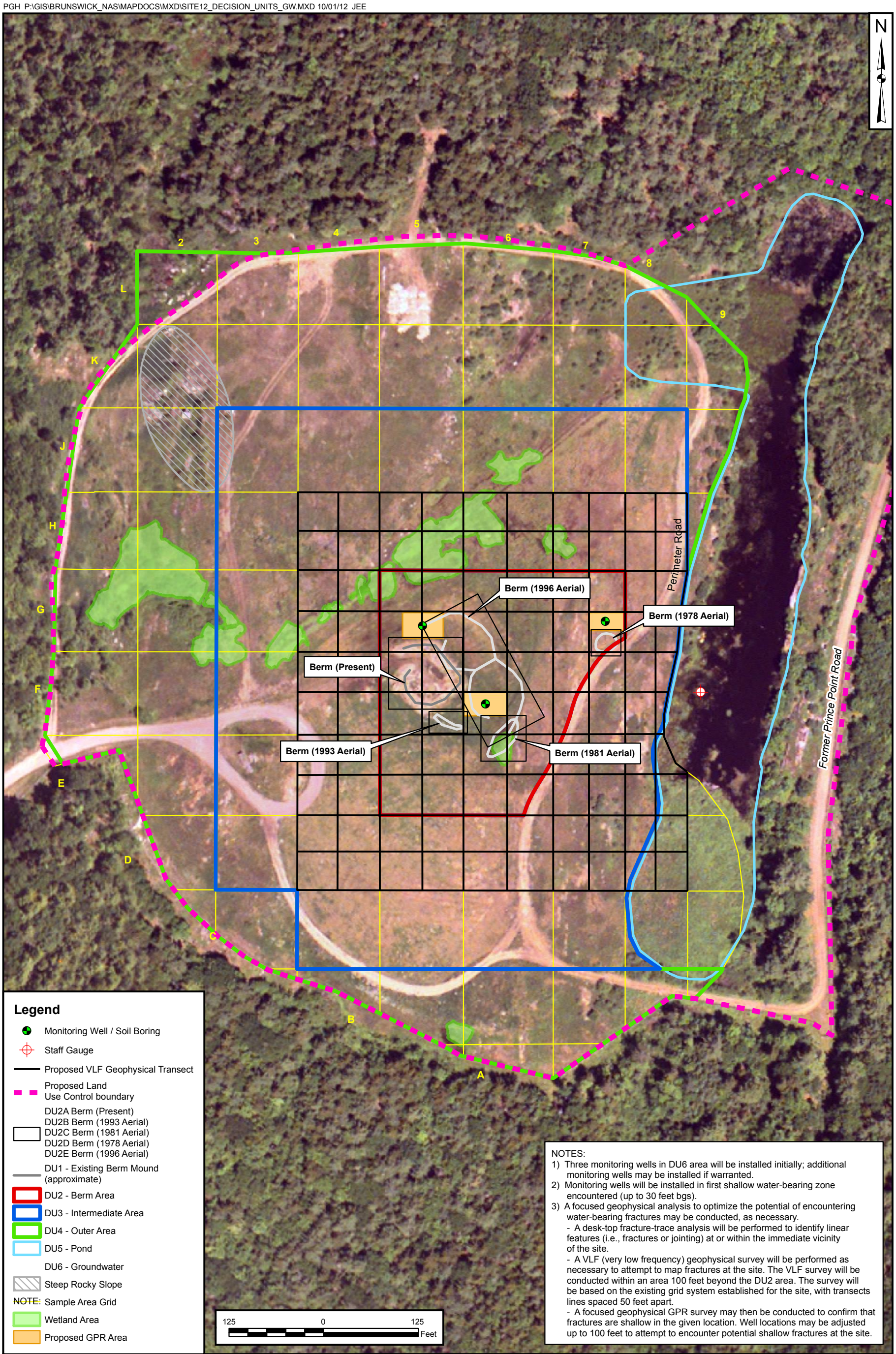


DRAWN BY	DATE	TETRA TECH	CONTRACT NUMBER	CTO NUMBER
J. ENGLISH	08/09/11		0645	WE09
CHECKED BY	DATE	SITE 12 EOD AREA	APPROVED BY	DATE
E. LOVE	10/01/12	DU5 (POND) SOIL AND SEDIMENT SAMPLE LOCATION MAP	___	___
REVISED BY	DATE	FORMER NAVAL AIR STATION BRUNSWICK	APPROVED BY	DATE
J. ENGLISH	10/01/12	BRUNSWICK, MAINE	___	___
SCALE			FIGURE NO.	REV
AS NOTED			FIGURE 17 - 4	1

PGH P:\GIS\BRUNSWICK_NAS\MAPDOCS\MXD\SITE12_DECISION_UNITS_GW.MXD 10/01/12 JEE



NOTES:
1) Three monitoring wells in DU6 area will be installed initially; additional monitoring wells may be installed if warranted.
2) Monitoring wells will be installed in first shallow water-bearing zone encountered (up to 30 feet bgs).
3) A focused geophysical analysis to optimize the potential of encountering water-bearing fractures may be conducted, as necessary.
- A desk-top fracture-trace analysis will be performed to identify linear features (i.e., fractures or jointing) at or within the immediate vicinity of the site.
- A VLF (very low frequency) geophysical survey will be performed as necessary to attempt to map fractures at the site. The VLF survey will be conducted within an area 100 feet beyond the DU2 area. The survey will be based on the existing grid system established for the site, with transects lines spaced 50 feet apart.
- A focused geophysical GPR survey may then be conducted to confirm that fractures are shallow in the given location. Well locations may be adjusted up to 100 feet to attempt to encounter potential shallow fractures at the site.

DRAWN BY J. ENGLISH	DATE 08/09/11	TETRA TECH	CONTRACT NUMBER 00645	CTO NUMBER WE09
CHECKED BY E. LOVE	DATE 10/01/12	SITE 12 EOD AREA DU6 (GROUNDWATER) GEOPHYSICS AND SAMPLE LOCATION MAP FORMER NAVAL AIR STATION BRUNSWICK BRUNSWICK, MAINE	APPROVED BY ___	DATE ___
REVISED BY J. ENGLISH	DATE 10/01/12		APPROVED BY ___	DATE ___
SCALE AS NOTED			FIGURE NO. FIGURE 17 - 5	REV 1

APPENDIX A

FIELD STANDARD OPERATING PROCEDURES (SOPS)

SOPs

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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

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

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

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

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

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

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

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

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

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

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

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

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

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

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

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

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

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

5.0 HEALTH AND SAFETY

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

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

Methods of avoiding these hazards are provided below.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6.0 PROCEDURES

6.1 General

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

CAUTION

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

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

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

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

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

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

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

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

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

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

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

6.2 Sampling, Monitoring, and Evacuation Equipment

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

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

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

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

6.3 Calculations of Well Volume

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

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

2. Determine well or inner casing diameter.

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

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

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

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

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

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

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

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

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

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

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

6.4 Evacuation of Static Water – Purging

6.4.1 General

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

6.4.2 Evacuation Devices

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

Bailers

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

Advantages of bailers include the following:

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

Limitations on the use of bailers include the following:

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

Safety concerns using a bailer include the following:

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

Control measures for these hazards are provided in Section 6.6.2.

Suction Pumps

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

~~Air-Lift and Gas-Lift Samplers~~

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

Submersible Pumps

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

Limitations of this class of pumps include the following:

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

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

~~Compressed Gases~~

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

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

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

Electrical Shock

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

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

To minimize or eliminate electrical generator hazards:

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

Lifting Hazards

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

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

6.5 Onsite Water Quality Testing

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

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

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

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

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

6.5.1 Measurement of pH

6.5.1.1 General

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

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

6.5.1.2 Principles of Equipment Operation

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

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

6.5.1.3 Equipment

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

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

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

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

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

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

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

pH Paper

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

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

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

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

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

5. Discard the used pH paper as trash.

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

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

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

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

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

6.5.2.2 Principles of Equipment Operation

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

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

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

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

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

6.5.2.4 Measurement Techniques for Specific Conductance

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

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

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

6.5.3 Measurement of Temperature

6.5.3.1 General

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

6.5.3.2 Equipment

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

6.5.3.3 Measurement Techniques for Water Temperature

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

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

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

If a temperature meter or probe is used:

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

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

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

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

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

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

6.5.4.2 Principles of Equipment Operation

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

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

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

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

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

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

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

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

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

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

8. Rinse the probe with deionized water.

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

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

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

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

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

6.5.5.2 Principles of Equipment Operation

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

6.5.5.3 Equipment

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

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

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

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

2. Thoroughly rinse the electrode with deionized water.

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

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

6.5.6 Measurement of Salinity

6.5.6.1 General

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

6.5.6.2 Principles of Equipment Operation

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

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

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

6.5.6.4 Measurement Techniques for Salinity

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

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

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

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

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

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

6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

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

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

6.5.7.2 Principles of Equipment Operation

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

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

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

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

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

- Manufacturer's operation manual.

6.5.7.4 Measurement Techniques for Turbidity

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

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

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

3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.

4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.

5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, and close the lid.

6. Immerse the electrode in the sample and measure the turbidity.

7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.

8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.

9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

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

- Background and objectives of sampling.

- Brief description of area and waste characterization.

- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated.

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

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

6.6.2 Sampling Methods as Related to Low-Flow Sampling

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

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

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

6.7.2 Equipment

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

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

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

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

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

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

6.7.3 Purging and Sampling Procedure

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.

- Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.

- Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.

- Prepare samples for shipping as per SOP SA-6.1.

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

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

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

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

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

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

Construction Material Abbreviations:

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

Other Abbreviations:

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

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

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

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

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

SAMPLING DATA:

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

PURGE DATA:

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

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

Circle If Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

ATTACHMENT C
EQUIPMENT CALIBRATION LOG

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

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

ATTACHMENT D
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

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

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

SIGNATURE(S): _____ **PAGE___OF___**

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE

This document applies to the collection of surface, near-surface, and subsurface soil samples exposed through hand digging, hand augering, drilling, or machine excavating at hazardous substance sites for laboratory testing, onsite visual examination, and onsite testing.

3.0 GLOSSARY

Composite Sample - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall not be collected for volatile organics analysis.

Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. TtNUS considers all confined space as permit-required confined spaces.

Grab Sample - One sample collected at one location and at one specific time.

Hand Auger - A sampling device used to extract soil from the ground.

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

Sample for Non-Volatile Analyses - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches OD. The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).

Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outside diameter (OD) and from 18 to 54 inches in length.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, selecting proposed sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

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

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

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

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

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

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

5.0 HEALTH AND SAFETY

Health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

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

Methods of avoiding these hazards are provided below.

Knee injuries – If kneeling is required during soil sampling, this could result in knee injuries from stones/foreign objects and general damage due to stress on the joints. To minimize this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.
- Stretch ligaments, tendons and muscles before, during and after. Take breaks as frequently as necessary.
- Report pre-existing conditions to the SSO if you feel this activity will aggravate an existing condition.

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

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

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

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.

- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.
- Secure items to be cut – do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken sample jars or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

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

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket**.

6.1 Overview

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a hazardous waste site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at hazardous waste sites.

6.2 Soil Sample Collection

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol or sodium bisulfate may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is needed.

Soil samples to be preserved by the laboratory are currently being collected using Method SW-846, 5035. For samples preserved in the field, laboratories are currently performing low-level analyses (sodium bisulfate preservation) and high- to medium-level analyses (methanol preservation) depending on the needs of the end user.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

6.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore™ sampler. Each sample shall be

obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore™ sampler when requested and purchased. Collect the sample in the following manner for each EnCore™ sampler:

1. Scene Safety - Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.

2. Wear the appropriate personal protective equipment (PPE). This will include, at a minimum, safety glasses and nitrile surgeon's gloves. If you must kneel on the ground or place equipment on the surface being sampled, cover the ground surface with plastic to minimize surface contamination of your equipment and clothing. Wear knee pads to protect your knees from kneeling on hard or uneven surfaces.

3. Load the Encore™ sampler into the T-handle with the plunger fully depressed.

4. Expose the area to be sampled using a hand trowel or similar device to remove surface debris.

5. Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.

6. When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.

7. Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.

8. With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.

9. Remove any surface soil from the outside of the sampler and place in the foil bag provided with the sampler. Good work hygiene practices and diligent decontamination procedures prevents the spread of contamination even on the outside of the containers.

10. Label the bag with appropriate information in accordance with SOP SA-6.3.

11. Place the full sampler inside a lined cooler with ice and cool to 4˚C ± 2 ˚C. Make sure any required trip blanks and temperature blanks are also in the cooler. Secure custody of the cooler in accordance with SOP SA-6.3.

12. Typically, collect three Encore™ samplers at each location. Consult the SAP or laboratory to determine the required number of Encore™ samplers to be collected.

13. The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the project planning documents.

Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each Encore™ sampler.

After the Encore™samples are collected, they should be placed on ice immediately and delivered to the laboratory within 48 hours (following the chain-of-custody and documentation procedures outlined in SOP SA-6.1). Samples must be preserved by the laboratory within 48 hours of sample collection.

6.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) and high- to medium-level (methanol preservation) methods.

Safety Reminder

When using chemicals in the field to preserve samples, the FOL and/or SSO must ensure that Materials Safety Data Sheets (MSDSs) have been provided with the chemicals to be used. They also must ensure that these chemicals have been added to the Chemical Inventory List contained within Section 5.0, Hazard Communication, of your Health and Safety Guidance Manual (HSGM). Lastly, but most importantly, the FOL and/or SSO must review the hazards with personnel using these chemicals and ensure that provisions are available for recommended PPE and emergency measures (e.g., eyewash, etc.).

Methanol Preservation (High to Medium Level):

Bottles may be pre-spiked with methanol in the laboratory or prepared in the field. Soil samples to be preserved in the field with methanol shall utilize 40 to 60 mL glass vials with septum-lined lids. Each sample bottle shall be filled with 25 mL of demonstrated analyte-free purge-and-trap grade methanol. The preferred method for adding methanol to the sample bottle is by removing the lid and using a pipette or scaled syringe to add the methanol directly to the bottle.

CAUTION

NEVER attempt to pipette by mouth

In situations where personnel are required to spike the septum using a hypodermic needle, the following provisions for handling sharps must be in place:

- Training of personnel regarding methods for handling of sharps
- Hard-sided containers for the disposal of sharps
- Provisions for treatment in cases where persons have received a puncture wound

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer's requirements.

The sample should be collected as follows:

1. Weigh the unused syringe and plunger to the nearest 0.01 gram.

2. Pull the plunger back and insert the syringe into the soil to be sampled.

3. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.

4. Weigh the sample and adjust until obtaining the required amount of sample.

5. Record the sample weight to the nearest 0.01 gram in the field logbook and/or on the sample log sheet.

6. Extrude the weighed soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.

7. If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.

8. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.

9. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

> ***CAUTION***
> Care should be taken when adding the soil to the sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as Encore™ or 2-ounce jar.

Bottles may be prepared in the laboratory or in the field with sodium bisulfate solution. Samples to be preserved in the field using the sodium bisulfate method are to be prepared and collected as follows:

1. Add 1 gram of sodium bisulfate to 5 mL of laboratory-grade deionized water in a 40 to 60 mL glass vial with septum-lined lid.

2. Collect the soil sample and record the sample weight to the nearest 0.01 gram in the field logbook or on the sample log sheet as described for methanol preservation

3. Add the weighed sample to the sample vial.

4. Collect duplicate samples using the methanol preservation method on a one-for-one sample basis because it is necessary for the laboratory to perform both low-level and medium-level analyses.

5. Place the samples on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

> ***NOTE***
> If lower detection limits are necessary, an option to field preserving with sodium bisulfate may be to collect EnCore™ samplers at a given sample location. Consult the planning documents to determine whether this is required. If it is, collect samples in accordance with the Encore™ sampling procedure above and then send all samplers to the laboratory to perform the required preservation and analyses.

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

1. With a stainless steel trowel or other approved tool, transfer a portion of soil to be sampled to a stainless steel bowl or disposable inert plastic tray.

2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.

3. Thoroughly mix the soil in the bowl or tray to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases, it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.

4. Transfer the mixed soil to the appropriate sample containers and close the containers.

5. Label the sample containers in accordance with SOP SA-6.3.

6. Place the containers in a cooler of ice as soon after collection as possible.

7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

> ***NOTE***
> Cooling may not be required for some samples depending on the scheduled analyses. Consult the planning documents if in doubt regarding correct sample preservation conditions. When in doubt – Cool to 4˚C.

> ***NOTE***
> Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

6.2.3 Procedure for Collecting Undisturbed Soil Samples

> ***NOTE***
> Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly used.

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:

1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:

   - Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.

REMEMBER
If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.

- Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the HASP.
- Review the Safe Work Permit prior to conducting the activity.
- Review the activity to be conducted.

2. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

CAUTION
The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.

3. Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.

4. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.

5. A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.

6. With the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

7. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.

8. Remove disturbed material in the upper end of the tube and measure the length of sample again.

9. After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.

10. Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.

11. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.

12. Mark the "up" direction on the side and upper end of the tube with indelible ink.

13. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).

14. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

CAUTION

To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.

CAUTION

A primary concern in the preparation of the wax plugs is the potential for the heat source and melted wax to cause a fire and/or burns. Follow the directions below to prevent injury or fire.

Electrical Heating

Using hot plates to melt the wax is acceptable. In an outdoor setting, make sure a Ground Fault Circuit Interrupter (GFCI) is employed within the electrical circuit. If a portable generator is used, ensure that the generator is an adequate distance from the sampling operation (at least 50 feet). Ensure that the extension cord is rated for the intended load and for outdoor use and is free from recognizable damage. Ensure flammable preservatives are not employed or stored near the hot plate. Although a Hot Work Permit is not required, scene safety evaluation by site personnel of the above elements is. As always, if a fire potential exists, the provisions for extinguishing must be immediately accessible as well as any provisions for first aid measures.

Open Flame

If an open flame is used, the following provisions are necessary:

- Complete a Hot Work Permit and any local permit required for elevated temperature applications. The Hot Work Permit, provided in your HASP, will aid the FOL and/or the SSO in ensuring that fire protection provisions (extinguishers, fire watches, etc.) are in place as well as ensuring that local requirements have been addressed.

- Ensure that water is available to address any wax splashes or contact. If possible, immerse the contacted area. Where this is not possible, run water over the area and apply cold compresses. The need for medical attention or first aid shall be determined on site under the direction of the SSO.

6.3 Surface Soil Sampling

The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.

> ***NOTE***
> Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.
>
> For the purposes of instruction, the terms "surface soil" and "near-surface soil" are used in this SOP as follows:
>
> - Surface soil - 0 to 6 inches bgs
> - Near-surface soil - 6 to 18 inches bgs
>
> If these intervals are defined differently in the planning documents, substitute the appropriate depth ranges.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Stainless steel hand auger, soil corer, or shovel.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in project planning document.
- Required PPE.
  - Nitrile surgeon's or latex gloves may be used, layered as necessary.
  - Safety glasses
  - Other – Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.

> ***Safety Reminder***
> The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP)
- Required decontamination equipment
- Required sample container(s)
- Wooden stakes or pin flags

- Sealable polyethylene bags (e.g., Ziploc® baggies)
- Heavy duty cooler
- Ice
- Chain-of-custody records and custody seals

When acquiring surface soil samples, use the following procedure:

1. Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross- contamination.
2. Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.
3. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the planning document.
4. Using decontaminated sampling tools, thoroughly mix in place a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.
5. Transfer the sample into those containers utilizing a stainless steel trowel.
6. Cap and securely tighten all sample containers.
7. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.
9. Site restoration – Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas when pedestrian traffic may exist.

6.4 Near-Surface Soil Sampling

Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.

To obtain near-surface soil samples, the following protocol shall be used:

1. With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.
2. Lever out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

3. Follow steps 1 through 9 of Section 6.3.

6.5 Subsurface Soil Sampling With a Hand Auger

A hand augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-inch lengths), and a T-handle connected to extension rods and to the auger bucket. A larger-diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes)
- Stainless steel mixing bowls
- The equipment listed in Section 6.3
- Miscellaneous hand tools as required to assemble and disassemble the hand auger units

CAUTION

Potential hazards associated with hand augering include:

- Muscle strain and sprain due to over twisting and/or over compromising yourself.
- Equipment failure due to excessive stress on the T-handle or rods through twisting. Failure of any of these components will result in a sudden release and potential injury due to that failure.

As in all situations, any intrusive activities that could damage underground utilities shall be proceeded by a Dig/Excavation permit/ticket. Call the Utility Locating service in the area or your Project Health and Safety Officer for more information. When in doubt – **Get the Ticket!**

To obtain soil samples using a hand auger, use the following procedure:

1. Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.
2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, litter, etc.).
3. Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.
4. As the auger bucket fills with soil, periodically remove any unneeded soil.

5. Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.

6. After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.

7. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.

8. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.

9. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.

10. Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.

11. Using a precleaned syringe or EnCore™ samplers, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.
12. Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl.

13. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.

14. Follow steps 4 through 7 listed in Section 6.3.

~~6.5.1 Sampling Using Stainless Steel Soil Corers~~

~~A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.~~

~~Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.~~

SAFETY REMINDER

Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:

- Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).

- Job rotation – Share the duties so that repetitive actions do not result in fatigue and injury.

- Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.

- Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.

- Do not over compromise yourself when applying force to the soil corer or hand auger. If there is a sudden release, it could result in a fall or muscle injury due to strain.

6.6 Subsurface Soil Sampling with a Split-Barrel Sampler

A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.

Safety Reminder

It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls.
- Equipment listed in Section 6.3.

The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):

1. Attach the split-barrel sampler to the sampling rods.

2. Lower the sampler into the borehole inside the hollow stem auger bits.

3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.

4. When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.

5. Detach the sampler from the drill rods.

6. Place the sampler securely in a vise so it can be opened using pipe wrenches.

> ***CAUTION***
> Pipe wrenches are used to separate the split spoon into several components. The driller's helper should not apply excessive force through the use of cheater pipes or push or pull in the direction where, if the wrench slips, hands or fingers will be trapped against an immovable object.

7. Remove the drive head and nosepiece with the wrenches, and open the sampler to reveal the soil sample.

8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.

9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings where encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).

10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl.

11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).

12. Follow steps 4 through 7 in Section 6.3.

6.7 ~~Subsurface Soil Sampling Using Direct-Push Technology~~

~~Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.~~

6.8 ~~Excavation and Sampling of Test Pits and Trenches~~

~~6.8.1 Applicability~~

~~This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.~~

CAUTION

During the excavation of trenches or ~~pits at hazardous waste sites, several health and safety concerns arise from the method of excavation. No personnel shall enter any test pit or excavation over 4 feet deep except as a last resort, and then only under direct supervision of a Competent Person (as defined in 29 CFR 1929.650 of Subpart P - Excavations). Whenever possible, all required chemical and lithological samples should be collected using the excavator bucket or other remote sampling apparatus. If entrance is required, all test pits or excavations must be stabilized by bracing the pit sides using specifically designed wooden, steel, or aluminum support structures or through sloping and benching. Personnel entering the excavation may be exposed to toxic or explosive gases and oxygen-deficient environments; therefore, monitoring will be conducted by the Competent Person to determine if it is safe to enter. Any entry into a trench greater than 4 feet deep will constitute a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. In all cases involving entry, substantial air monitoring, before entry, appropriate respiratory gear and protective clothing determination, and rescue provisions are mandatory. There must be at least three people present at the immediate site before entry by one of the field team members. This minimum number of people will increase based on the potential hazards or complexity of the work to be performed. The reader shall refer to OSHA regulations 29 CFR 1926.650, 29 CFR 1910.120, 29 CFR 1910.134, and 29 CFR 1910.146. High-hazard entries such as this will be supported by members of the Health Sciences Group professionally trained in these activities.~~

~~Excavations are generally not practical where a depth of more than about 15 to 20 feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15 feet are required, the data are usually obtained through test borings instead of test pits.~~

~~In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.~~

~~6.8.2 Test Pit and Trench Excavation~~

~~Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).~~

~~Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:~~

- ~~The purpose and extent of the exploration~~

- ~~The space required for efficient excavation~~
- ~~The chemicals of concern~~
- ~~The economics and efficiency of available equipment~~

~~Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.~~

~~Equipment~~	~~Typical Widths, in Feet~~
~~Trenching machine~~	~~0.25 to 1.0~~
~~Backhoe/Track Hoe~~	~~2 to 6~~

~~The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.~~

~~The construction of test pits and trenches shall be planned and designed in advance as much as possible. However, the following field conditions may necessitate revisions to the initial plans:~~

- ~~Subsurface utilities~~
- ~~Surface and subsurface encumbrances~~
- ~~Vehicle and pedestrian traffic patterns~~
- ~~Purpose for excavation (e.g., the excavation of potential ordnance items)~~

~~The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.~~

~~No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example,~~

~~samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.~~

~~Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.~~

~~Where possible excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:~~

- ~~Trench covers/street plates~~
- ~~Fences encompassing the entire excavation intended to control access~~
- ~~Warning signs warning personnel of the hazards~~
- ~~Amber flashing lights to demarcate boundaries of the excavation at night~~

~~Excavations left open will have emergency means to exit should someone accidentally enter.~~

~~6.8.3 Sampling in Test Pits and Trenches~~

~~6.8.3.1 General~~

~~Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.~~

~~Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the project-specific HASP.~~

~~The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.~~

~~In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.~~

~~6.8.3.2 Sampling Equipment~~

~~The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:~~

- ~~Backhoe or other excavating machinery.~~
- ~~Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.~~
- ~~Sample container - bucket with locking lid for large samples; appropriate bottle ware for chemical or geotechnical analysis samples.~~
- ~~Polyethylene bags for enclosing sample containers; buckets.~~
- ~~Remote sampler consisting of 10 foot sections of steel conduit (1 inch diameter), hose clamps, and right angle adapter for conduit (see Attachment D).~~

~~6.8.3.3 Sampling Methods~~

~~The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.~~

- ~~Excavate the trench or pit in several 0.5- to 1.0 foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.~~
- ~~After each increment:~~
  - ~~the operator shall wait while the sampler inspects the test pit from grade level~~
  - ~~the sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet i or where lithological changes are noted.~~
- ~~The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:~~
  - ~~Any fluid phase, including groundwater seepage, is encountered in the test pit~~
  - ~~Any drums, other potential waste containers, obstructions, or utility lines are encountered~~
  - ~~Distinct changes of material being excavated are encountered~~

~~This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.~~

~~For obtaining test pit samples from grade level, the following procedure shall be followed:~~

- ~~Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.~~
- ~~Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)~~

- ~~Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:~~

  ~~a. The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.~~

  ~~b. The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.~~

  ~~c. After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.~~

  ~~d. When signaled by the operator that it is safe to do, the sampler will approach the bucket.~~

  ~~e. The soil shall be monitored with a photoionization or flame ionization detector (PID or FID) as directed in the project -specific planning documents.~~

  ~~f. The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.~~

- ~~If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.~~

> ~~***CAUTION***~~
>
> ~~Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.~~

- ~~Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:~~

  ~~a. Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bucket.~~

  ~~b. Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.~~

  ~~c. Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.~~

- ~~Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.~~

~~6.8.3.4 In-Pit Sampling~~

~~Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.~~

~~In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:~~

- ~~There are no practical alternative means of obtaining such data.~~
- ~~The SSO and Competent Person determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.~~
- ~~A company-designated Competent Person determines that the pit/trench is stable trough soil classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.~~

~~If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.~~

~~A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self rescue or assisted self rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon.~~

~~6.8.3.5 Geotechnical Sampling~~

~~In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:~~

- ~~Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.~~
- ~~Suitable driving (e,g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.~~
- ~~Knives, spatulas, and other suitable devices for trimming hand-carved samples.~~
- ~~Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.~~
- ~~Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.~~

~~Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.~~

~~Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.~~

~~A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to remove the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SOPs SA-6.3 and SA-6.1.~~

~~6.8.4 Backfilling of Trenches and Test Pits~~

~~All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.~~

~~Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.~~

~~After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.~~

~~If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.~~

6.9 Records

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining GPS coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.

Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs if required
- Groundwater levels
- PID/FID/LEL/O_2 meter readings
- Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists

- Soil type classification

7.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

NUS Corporation, 1986. Hazardous Material Handling Training Manual.

NUS Corporation and CH2M Hill, August, 1987. Compendium of Field Operation Methods. Prepared for the U.S. EPA.

OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

OSHA, Confined Space Entry 29 CFR 1910.146.

USEPA, November 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual.

ATTACHMENT A
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

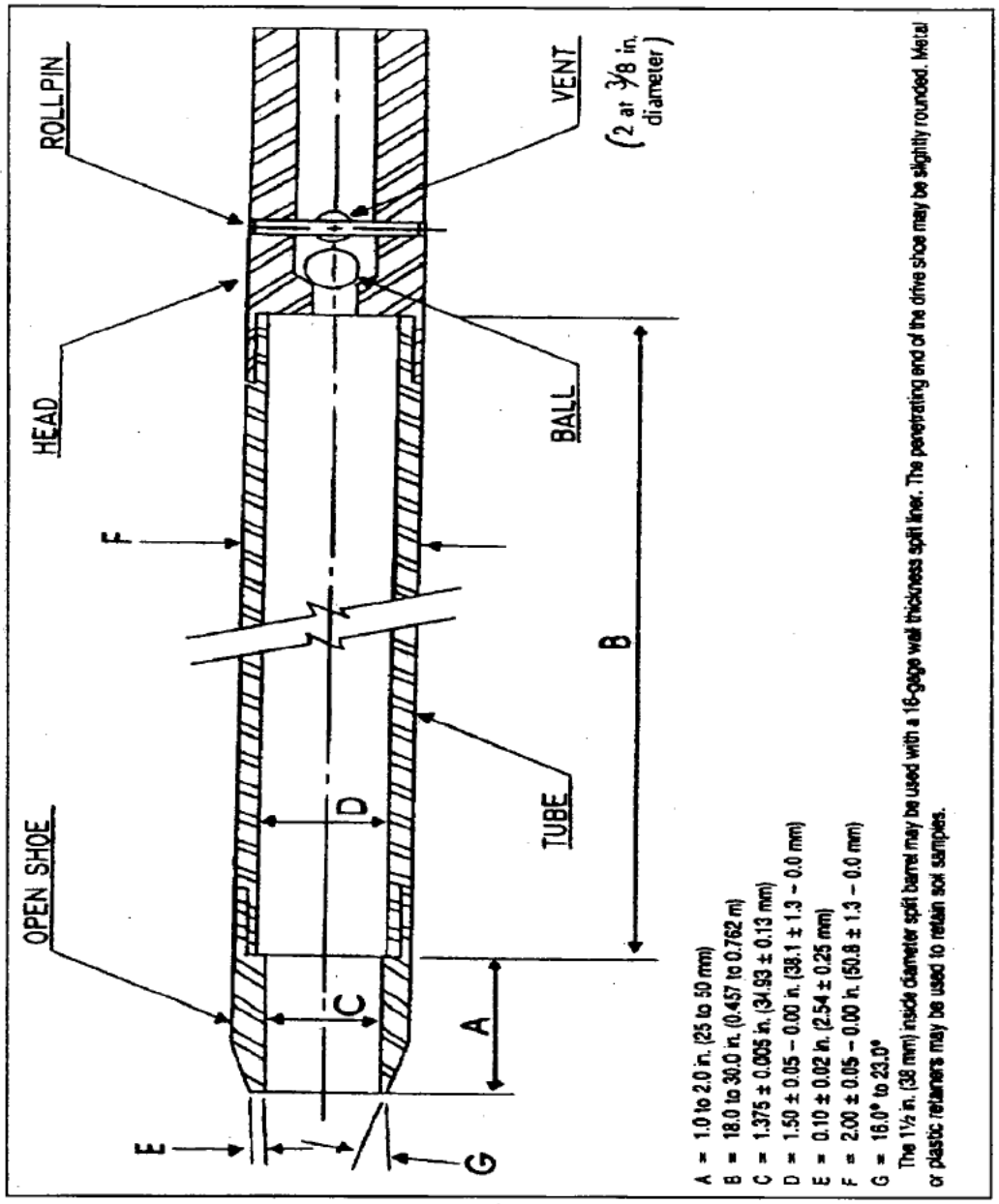
Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

ATTACHMENT B
SPLIT-SPOON SAMPLER



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

ATTACHMENT C
TEST PIT LOG

Tetra Tech NUS, Inc.

TEST PIT LOG

Page ___ of ___

PROJECT NAME: _____ TEST PIT No.: _____
PROJECT NUMBER: _____ DATE: _____
LOCATION: _____ GEOLOGIST: _____

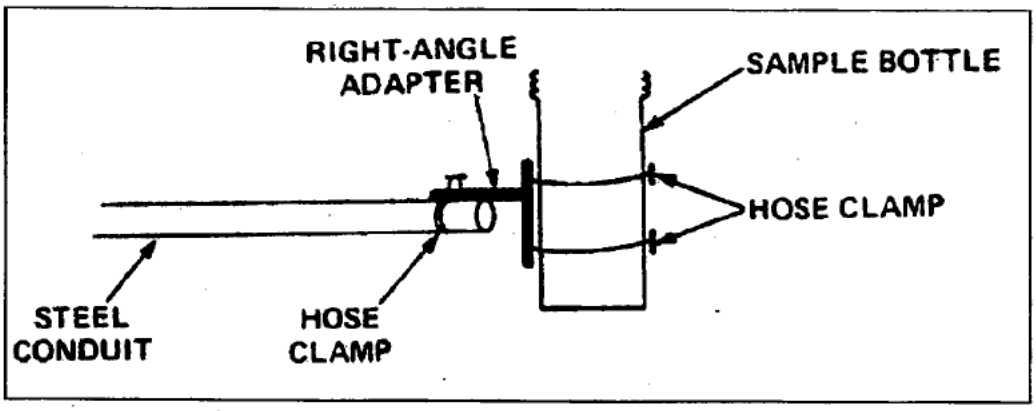
Depth (Ft.)	Lithology Change (Depth/Ft.)	MATERIAL DESCRIPTION Soil/Waste Characteristics (lithology, density, color, etc.)	USCS	Remarks	PID/FID READING Source (ppm)	BZ (ppm)

TEST PIT CROSS SECTION AND / OR PLAN VIEW

REMARKS: _____

PHOTO LOG: _____

ATTACHMENT D
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING



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1.0 PURPOSE

The purpose of this document is to establish standard procedures and technical guidance on borehole and sample logging.

2.0 SCOPE

These procedures provide descriptions of the standard techniques for borehole and sample logging. These techniques shall be used for each boring logged to provide consistent descriptions of subsurface lithology. While experience is the only method to develop confidence and accuracy in the description of soil and rock, the field geologist/engineer can do a good job of classification by careful, thoughtful observation and by being consistent throughout the classification procedure.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Site Geologist. Responsible for supervising all boring activities and assuring that each borehole is completely logged. If more than one rig is being used on site, the Site Geologist must make sure that each field geologist is properly trained in logging procedures. A brief review or training session may be necessary prior to the start up of the field program and/or upon completion of the first boring.

5.0 PROCEDURES

The classification of soil and rocks is one of the most important jobs of the field geologist/engineer. To maintain a consistent flow of information, it is imperative that the field geologist/engineer understand and accurately use the field classification system described in this SOP. This identification is based on visual examination and manual tests.

5.1 Materials Needed

When logging soil and rock samples, the geologist or engineer may be equipped with the following:

- Rock hammer
- Knife
- Camera
- Dilute hydrochloric acid (HCl)
- Ruler (marked in tenths and hundredths of feet)
- Hand Lens

5.2 Classification of Soils

All data shall be written directly on the boring log (Figure 1) or in a field notebook if more space is needed. Details on filling out the boring log are discussed in Section 5.5.

FIGURE 1
BORING LOG (EXAMPLE)

BORING LOG

Page ___ of ___

PROJECT NAME: _____ BORING NUMBER: _____
PROJECT NUMBER: _____ DATE: _____
DRILLING COMPANY: _____ GEOLOGIST: _____
DRILLING RIG: _____ DRILLER: _____

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

Drilling Area Background (ppm): ____

Remarks: _____

Converted to Well: Yes _____ No _____ Well I.D. #: _____

FIGURE 1 (CONTINUED)

SOIL TERMS

UNIFIED SOIL CLASSIFICATION (USCS)

COARSE-GRAINED SOILS More Than Half of Material is LARGER Than No. 200 Sieve Size					FINE-GRAINED SOILS More Than Half of Material is SMALLER Than No. 200 Sieve Size						
FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)			GROUP SYMBOL	TYPICAL NAMES	FIELD IDENTIFICATION PROCEDURES (Excluding Particles Larger Than 3 Inches and Basing Fractions on Estimated Weights)				GROUP SYMBOL	TYPICAL NAMES
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size					
						DRY STRENGTH (Crushing Characteristics)	DILATANCY (Reaction to Shaking)	TOUGHNESS (Consistency Near Plastic Limit)		
GRAVELS (More Than 50% of Coarse Fraction Larger Than 4.75 mm)	CLEAN GRAVELS (Less than 5% Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	Well graded gravels, gravel-sand mixtures, little or no fines.	SILTS AND CLAYS Liquid Limit < 50	None to Slight	Quick to Slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.		Medium to High	None to Very Slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
	GRAVELS WITH FINES (More Than 12% Fines)	Non-plastic fines (for identification procedures, see ML)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures.		Slight to Medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity.
		Plastic fines (for identification procedures, see CL)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures.	SILTS AND CLAYS Liquid Limit > 50	Slight to Medium	Slow to None	Slight to Medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
SANDS (More Than 50% of Coarse Fraction Smaller Than 4.75 mm)	CLEAN SANDS (Less Than 5% Fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	SW	Well graded sand, gravelly sands, little or no fines.		High to Very High	None	High	CH	Inorganic clays of high plasticity, fat clays.
		Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	Poorly graded sands, gravelly sands, little or no fines.		Medium to High	None to Very Slow	Slight to Medium	OH	Organic clays of medium to high plasticity.
	SANDS WITH FINES (More Than 12% Fines)	Non-plastic fines (for identification procedures, see ML)	SM	Silty sands, poorly graded sand-silt mixtures.	HIGHLY ORGANIC SOILS	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			Pt	Peat and other organic soils
		Plastic fines (for identification procedures, see CL)	SC	Clayey sands, poorly graded sand-clay mixtures.						

Boundary classifications: Soils possessing characteristics of two groups are designated by combining group symbols. For example, GW-GC, well graded gravel-sand mixture with clay binder.
All sieve sizes on this chart are U.S. Standard.

DENSITY OF GRANULAR SOILS	
DESIGNATION	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT
Very Loose	0-4
Loose	5-10
Medium Loose	11-30
Dense	31-50
Very Dense	Over 50

CONSISTENCY OF COHESIVE SOILS			
CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TONS/SQ. FT.)	STANDARD PENETRATION RESISTANCE-BLOWS/FOOT	FIELD IDENTIFICATION METHODS
Very Soft	Less than 0.25	0 to 2	Easily penetrated several inches by fist
Soft	0.25 to 0.50	2 to 4	Easily penetrated several inches by thumb.
Medium Stiff	0.50 to 1.0	4 to 8	Can be penetrated several inches by thumb.
Stiff	1.0 to 2.0	8 to 15	Readily indented by thumb.
Very Stiff	2.0 to 4.0	15 to 30	Readily indented by thumbnail.
Hard	More than 4.0	Over 30	Indented with difficulty by thumbnail.

ROCK TERMS

ROCK HARDNESS (FROM CORE SAMPLES)			ROCK BROKENNESS		
Descriptive Terms	Scratcher or Knife Effects	Hammer Effects	Descriptive Terms	Abbreviation	Spacing
Soft	Easily Gouged	Crushes when pressed with hammer	Very Broken	(V.Br.)	< 2"
Medium Soft	Can be Gouged	Breaks (one blow); crumbly edges	Broken	(Br.)	2"-6"
Medium Hard	Can be scratched	Breaks (one blow); sharp edges	Blocky	(Bl.)	6"-30"
Hard	Cannot be scratched	Breaks considerably (several blows); sharp edges	Massive	(M.)	30"-96"

LEGEND :

SOIL SAMPLES - TYPES	ROCK SAMPLES - TYPES	WATER LEVELS	
5-1/2" Split Barrel Sample	X-NX (Conventional) Core (2-1/8" O.D.)	12/96	
STP 3" O.D. Undisturbed Sample	ONQ (Winline) Core (2-1/8" O.D.)		▼ 12.5' Initial Level w/Date & Depth
O - Other Samples, Specify in Remarks	Z - Other Core Sizes, Specify in Remarks	12/96	
			▼ 12.5' Stabilized Level w/Date & Depth

5.2.1 USCS Classification

Soils are to be classified according to the Unified Soil Classification System (USCS). This method of classification is detailed in Figure 1 (Continued).
This method of classification identifies soil types on the basis of grain size and cohesiveness.

Fine-grained soils, or fines, are smaller than the No. 200 sieve and are of two types: silt (M) and clay (C). Some classification systems define size ranges for these soil particles, but for field classification purposes, they are identified by their respective behaviors. Organic material (O) is a common component of soil but has no size range; it is recognized by its composition. The careful study of the USCS will aid in developing the competence and consistency necessary for the classification of soils.

Coarse-grained soils shall be divided into rock fragments, sand, or gravel. The terms sand and gravel not only refer to the size of the soil particles but also to their depositional history. To insure accuracy in description, the term rock fragments shall be used to indicate angular granular materials resulting from the breakup of rock. The sharp edges typically observed indicate little or no transport from their source area, and therefore the term provides additional information in reconstructing the depositional environment of the soils encountered. When the term "rock fragments" is used it shall be followed by a size designation such as "(1/4 inchΦ-1/2 inchΦ)" or "coarse-sand size" either immediately after the entry or in the remarks column. The USCS classification would not be affected by this variation in terms.

5.2.2 Color

Soil colors shall be described utilizing a single color descriptor preceded, when necessary, by a modifier to denote variations in shade or color mixtures. A soil could therefore be referred to as "gray" or "light gray" or "blue-gray." Since color can be utilized in correlating units between sampling locations, it is important for color descriptions to be consistent from one boring to another.

Colors must be described while the sample is still moist. Soil samples shall be broken or split vertically to describe colors. Samplers tend to smear the sample surface creating color variations between the sample interior and exterior.

The term "mottled" shall be used to indicate soils irregularly marked with spots of different colors. Mottling in soils usually indicates poor aeration and lack of good drainage.

Soil Color Charts shall not be used unless specified by the project manager.

5.2.3 Relative Density and Consistency

To classify the relative density and/or consistency of a soil, the geologist is to first identify the soil type. Granular soils contain predominantly sands and gravels. They are noncohesive (particles do not adhere well when compressed). Finer-grained soils (silts and clays) are cohesive (particles will adhere together when compressed).

The density of noncohesive, granular soils is classified according to standard penetration resistances obtained from split-barrel sampling performed according to the methods detailed in Standard Operating Procedures GH-1.3 and SA-1.3. Those designations are:

Designation	Standard Penetration Resistance (Blows per Foot)
Very loose	0 to 4
Loose	5 to 10
Medium dense	11 to 30
Dense	31 to 50
Very dense	Over 50

Standard penetration resistance is the number of blows required to drive a split-barrel sampler with a 2-inch outside diameter 12 inches into the material using a 140-pound hammer falling freely through 30 inches. The sampler is driven through an 18-inch sample interval, and the number of blows is recorded for each 6-inch increment. The density designation of granular soils is obtained by adding the number of blows required to penetrate the last 12 inches of each sample interval. It is important to note that if gravel or rock fragments are broken by the sampler or if rock fragments are lodged in the tip, the resulting blow count will be erroneously high, reflecting a higher density than actually exists. This shall be noted on the log and referenced to the sample number. Granular soils are given the USCS classifications GW, GP, GM, SW, SP, SM, GC, or SC (see Figure 1).

The consistency of cohesive soils is determined by performing field tests and identifying the consistency as shown in Figure 2.

Cohesive soils are given the USCS classifications ML, MH, CL, CH, OL, or OH (see Figure 1).

The consistency of cohesive soils is determined either by blow counts, a pocket penetrometer (values listed in the table as Unconfined Compressive Strength), or by hand by determining the resistance to penetration by the thumb. The pocket penetrometer and thumb determination methods are conducted on a selected sample of the soil, preferably the lowest 0.5 foot of the sample in the split-barrel sampler. The sample shall be broken in half and the thumb or penetrometer pushed into the end of the sample to determine the consistency. Do not determine consistency by attempting to penetrate a rock fragment. If the sample is decomposed rock, it is classified as a soft decomposed rock rather than a hard soil. Consistency shall not be determined solely by blow counts. One of the other methods shall be used in conjunction with it. The designations used to describe the consistency of cohesive soils are shown in Figure 2.

5.2.4 Weight Percentages

In nature, soils are comprised of particles of varying size and shape, and are combinations of the various grain types. The following terms are useful in the description of soil:

Terms of Identifying Proportion of the Component	Defining Range of Percentages by Weight
Trace	0 - 10 percent
Some	11 - 30 percent
Adjective form of the soil type (e.g., "sandy")	31 - 50 percent

FIGURE 2

CONSISTENCY FOR COHESIVE SOILS

Consistency	Standard Penetration Resistance (Blows per Foot)	Unconfined Compressive Strength (Tons/Sq. Foot by pocket penetration)	Field Identification
Very soft	0 to 2	Less than 0.25	Easily penetrated several inches by fist
Soft	2 to 4	0.25 to 0.50	Easily penetrated several inches by thumb
Medium stiff	4 to 8	0.50 to 1.0	Can be penetrated several inches by thumb with moderate effort
Stiff	8 to 15	1.0 to 2.0	Readily indented by thumb but penetrated only with great effort
Very stiff	15 to 30	2.0 to 4.0	Readily indented by thumbnail
Hard	Over 30	More than 4.0	Indented with difficulty by thumbnail

Examples:

- Silty fine sand: 50 to 69 percent fine sand, 31 to 50 percent silt.
- Medium to coarse sand, some silt: 70 to 80 percent medium to coarse sand, 11 to 30 percent silt.
- Fine sandy silt, trace clay: 50 to 68 percent silt, 31 to 49 percent fine sand, 1 to 10 percent clay.
- Clayey silt, some coarse sand: 70 to 89 percent clayey silt, 11 to 30 percent coarse sand.

5.2.5 Moisture

Moisture content is estimated in the field according to four categories: dry, moist, wet, and saturated. In dry soil, there appears to be little or no water. Saturated samples obviously have all the water they can hold. Moist and wet classifications are somewhat subjective and often are determined by the individual's judgment. A suggested parameter for this would be calling a soil wet if rolling it in the hand or on a porous surface liberates water, i.e., dirties or muddies the surface. Whatever method is adopted for describing moisture, it is important that the method used by an individual remains consistent throughout an entire drilling job.

Laboratory tests for water content shall be performed if the natural water content is important.

5.2.6 Stratification

Stratification can only be determined after the sample barrel is opened. The stratification or bedding thickness for soil and rock is depending on grain size and composition. The classification to be used for stratification description is shown in Figure 3.

5.2.7 Texture/Fabric/Bedding

The texture/fabric/bedding of the soil shall be described. Texture is described as the relative angularity of the particles: rounded, subrounded, subangular, and angular. Fabric shall be noted as to whether the particles are flat or bulky and whether there is a particular relation between particles (i.e., all the flat particles are parallel or there is some cementation). The bedding or structure shall also be noted (e.g., stratified, lensed, nonstratified, heterogeneous varved).

5.2.8 Summary of Soil Classification

In summary, soils shall be classified in a similar manner by each geologist/engineer at a project site. The hierarchy of classification is as follows:

- Density and/or consistency
- Color
- Plasticity (Optional)
- Soil types
- Moisture content
- Stratification
- Texture, fabric, bedding
- Other distinguishing features

FIGURE 3

BEDDING THICKNESS CLASSIFICATION

Thickness (metric)	Thickness (Approximate English Equivalent)	Classification
> 1.0 meter	> 3.3'	Massive
30 cm - 1 meter	1.0' - 3.3'	Thick Bedded
10 cm - 30 cm	4" - 1.0'	Medium Bedded
3 cm - 10 cm	1" - 4"	Thin Bedded
1 cm - 3 cm	2/5" - 1"	Very Thin Bedded
3 mm - 1 cm	1/8" - 2/5"	Laminated
1 mm - 3 mm	1/32" - 1/8"	Thinly Laminated
< 1 mm	<1/32"	Micro Laminated

(Weir, 1973 and Ingram, 1954)

5.3 Classification of Rocks

Rocks are grouped into three main divisions: sedimentary, igneous and metamorphic. Sedimentary rocks are by far the predominant type exposed at the earth's surface. The following basic names are applied to the types of rocks found in sedimentary sequences:

- Sandstone - Made up predominantly of granular materials ranging between 1/16 to 2 mm in diameter.
- Siltstone - Made up of granular materials less than 1/16 to 1/256 mm in diameter. Fractures irregularly. Medium thick to thick bedded.
- Claystone - Very fine-grained rock made up of clay and silt-size materials. Fractures irregularly. Very smooth to touch. Generally has irregularly spaced pitting on surface of drilled cores.
- Shale - A fissile very fine-grained rock. Fractures along bedding planes.
- Limestone - Rock made up predominantly of calcite ($CaCO_3$). Effervesces strongly upon the application of dilute hydrochloric acid.
- Coal - Rock consisting mainly of organic remains.
- Others - Numerous other sedimentary rock types are present in lesser amounts in the stratigraphic record. The local abundance of any of these rock types is dependent upon the depositional history of the area. Conglomerate, halite, gypsum, dolomite, anhydrite, lignite, etc. are some of the rock types found in lesser amounts.

In classifying a sedimentary rock the following hierarchy shall be noted:

- Rock type
- Color
- Bedding thickness
- Hardness
- Fracturing
- Weathering
- Other characteristics

5.3.1 Rock Type

As described above, there are numerous types of sedimentary rocks. In most cases, a rock will be a combination of several grain types, therefore, a modifier such as a sandy siltstone, or a silty sandstone can be used. The modifier indicates that a significant portion of the rock type is composed of the modifier. Other modifiers can include carbonaceous, calcareous, siliceous, etc.

Grain size is the basis for the classification of clastic sedimentary rocks. Figure 4 is the Udden-Wentworth classification that will be assigned to sedimentary rocks. The individual boundaries are slightly different than the USCS subdivision for soil classification. For field determination of grain sizes, a scale can be used for the coarse grained rocks. For example, the division between siltstone and claystone may not be measurable in the field. The boundary shall be determined by use of a hand lens. If the grains cannot be seen with the naked eye but are distinguishable with a hand lens, the rock is a siltstone. If the grains are not distinguishable with a hand lens, the rock is a claystone.

FIGURE 4

GRAIN SIZE CLASSIFICATION FOR ROCKS

Particle Name	Grain Size Diameter
Cobbles	> 64 mm
Pebbles	4 - 64 mm
Granules	2 - 4 mm
Very Coarse Sand	1 - 2 mm
Coarse Sand	0.5 - 1 mm
Medium Sand	0.25 - 0.5 mm
Fine Sand	0.125 - 0.25 mm
Very Fine Sand	0.0625 - 0.125 mm
Silt	0.0039 - 0.0625 mm

After Wentworth, 1922

5.3.2 Color

The color of a rock can be determined in a similar manner as for soil samples. Rock core samples shall be classified while wet, when possible, and air cored samples shall be scraped clean of cuttings prior to color classifications.

Rock color charts shall not be used unless specified by the Project Manager.

5.3.3 Bedding Thickness

The bedding thickness designations applied to soil classification (see Figure 3) will also be used for rock classification.

5.3.4 Hardness

The hardness of a rock is a function of the compaction, cementation, and mineralogical composition of the rock. A relative scale for sedimentary rock hardness is as follows:

- Soft - Weathered, considerable erosion of core, easily gouged by screwdriver, scratched by fingernail. Soft rock crushes or deforms under pressure of a pressed hammer. This term is always used for the hardness of the saprolite (decomposed rock which occupies the zone between the lowest soil horizon and firm bedrock).

- Medium soft - Slight erosion of core, slightly gouged by screwdriver, or breaks with crumbly edges from single hammer blow.

- Medium hard - No core erosion, easily scratched by screwdriver, or breaks with sharp edges from single hammer blow.

- Hard - Requires several hammer blows to break and has sharp conchoidal breaks. Cannot be scratched with screwdriver.

Note the difference in usage here of the works "scratch" and "gouge." A scratch shall be considered a slight depression in the rock (do not mistake the scraping off of rock flour from drilling with a scratch in the rock itself), while a gouge is much deeper.

5.3.5 Fracturing

The degree of fracturing or brokenness of a rock is described by measuring the fractures or joint spacing. After eliminating drilling breaks, the average spacing is calculated and the fracturing is described by the following terms:

- Very broken (V. BR.) - Less than 2-inch spacing between fractures
- Broken (BR.) - 2-inch to 1-foot spacing between fractures
- Blocky (BL.) - 1- to 3-foot spacing between fractures
- Massive (M.) - 3 to 10-foot spacing between fractures

The structural integrity of the rock can be approximated by calculating the Rock Quality Designation (RQD) of cores recovered. The RQD is determined by adding the total lengths of all pieces exceeding 4 inches and dividing by the total length of the coring run, to obtain a percentage.

Method of Calculating RQD
(After Deere, 1964)

$$RQD\ \% = r/l \times 100$$

r = Total length of all pieces of the lithologic unit being measured, which are greater than 4 inches length, and have resulted from natural breaks. Natural breaks include slickensides, joints, compaction slicks, bedding plane partings (not caused by drilling), friable zones, etc.

l = Total length of the coring run.

5.3.6 Weathering

The degree of weathering is a significant parameter that is important in determining weathering profiles and is also useful in engineering designs. The following terms can be applied to distinguish the degree of weathering:

- Fresh - Rock shows little or no weathering effect. Fractures or joints have little or no staining and rock has a bright appearance.
- Slight - Rock has some staining which may penetrate several centimeters into the rock. Clay filling of joints may occur. Feldspar grains may show some alteration.
- Moderate - Most of the rock, with exception of quartz grains, is stained. Rock is weakened due to weathering and can be easily broken with hammer.
- Severe - All rock including quartz grains is stained. Some of the rock is weathered to the extent of becoming a soil. Rock is very weak.

5.3.7 Other Characteristics

The following items shall be included in the rock description:

- Description of contact between two rock units. These can be sharp or gradational.
- Stratification (parallel, cross stratified).
- Description of any filled cavities or vugs.
- Cementation (calcareous, siliceous, hematitic).
- Description of any joints or open fractures.
- Observation of the presence of fossils.
- Notation of joints with depth, approximate angle to horizontal, any mineral filling or coating, and degree of weathering.

All information shown on the boring logs shall be neat to the point where it can be reproduced on a copy machine for report presentation. The data shall be kept current to provide control of the drilling program and to indicate various areas requiring special consideration and sampling.

5.3.8 Additional Terms Used in the Description of Rock

The following terms are used to further identify rocks:

- Seam - Thin (12 inches or less), probably continuous layer.
- Some - Indicates significant (15 to 40 percent) amounts of the accessory material. For example, rock composed of seams of sandstone (70 percent) and shale (30 percent) would be "sandstone -- some shale seams."
- Few - Indicates insignificant (0 to 15 percent) amounts of the accessory material. For example, rock composed of seam of sandstone (90 percent) and shale (10 percent) would be "sandstone -- few shale seams."
- Interbedded - Used to indicate thin or very thin alternating seams of material occurring in approximately equal amounts. For example, rock composed of thin alternating seams of sandstone (50 percent) and shale (50 percent) would be "interbedded sandstone and shale."
- Interlayered - Used to indicate thick alternating seams of material occurring in approximately equal amounts.

The preceding sections describe the classification of sedimentary rocks. The following are some basic names that are applied to igneous rocks:

- Basalt - A fine-grained extrusive rock composed primarily of calcic plagioclase and pyroxene.
- Rhyolite - A fine-grained volcanic rock containing abundant quartz and orthoclase. The fine-grained equivalent of a granite.
- Granite - A coarse-grained plutonic rock consisting essentially of alkali feldspar and quartz.
- Diorite - A coarse-grained plutonic rock consisting essentially of sodic plagioclase and hornblende.
- Gabbro - A coarse-grained plutonic rock consisting of calcic plagioclase and clinopyroxene. Loosely used for any coarse-grained dark igneous rock.

The following are some basic names that are applied to metamorphic rocks:

- Slate - A very fine-grained foliated rock possessing a well developed slaty cleavage. Contains predominantly chlorite, mica, quartz, and sericite.
- Phyllite - A fine-grained foliated rock that splits into thin flaky sheets with a silky sheen on cleavage surface.
- Schist - A medium to coarse-grained foliated rock with subparallel arrangement of the micaceous minerals which dominate its composition.
- Gneiss - A coarse-grained foliated rock with bands rich in granular and platy minerals.
- Quartzite - A fine- to coarse-grained nonfoliated rock breaking across grains, consisting essentially of quartz sand with silica cement.

5.4 Abbreviations

Abbreviations may be used in the description of a rock or soil. However, they shall be kept at a minimum. Following are some of the abbreviations that may be used:

C	-	Coarse	Lt	-	Light	Yl	-	Yellow
Med	-	Medium	BR	-	Broken	Or	-	Orange
F	-	Fine	BL	-	Blocky	SS	-	Sandstone
V	-	Very	M	-	Massive	Sh	-	Shale
Sl	-	Slight	Br	-	Brown	LS	-	Limestone
Occ	-	Occasional	Bl	-	Black	Fgr	-	Fine-grained
Tr	-	Trace						

5.5 Boring Logs and Documentation

This section describes in more detail the procedures to be used in completing boring logs in the field. Information obtained from the preceding sections shall be used to complete the logs. A sample boring log has been provided as Figure 5.

The field geologist/engineer shall use this example as a guide in completing each boring log. Each boring log shall be fully described by the geologist/engineer as the boring is being drilled. Every sheet contains space for 25 feet of log. Information regarding classification details is provided either on the back of the boring log or on a separate sheet, for field use.

5.5.1 Soil Classification

- Identify site name, boring number, job number, etc. Elevations and water level data to be entered when surveyed data is available.

- Enter sample number (from SPT) under appropriate column. Enter depth sample was taken from (1 block = 1 foot). Fractional footages, i.e., change of lithology at 13.7 feet, shall be lined off at the proportional location between the 13- and 14-foot marks. Enter blow counts (Standard Penetration Resistance) diagonally (as shown). Standard penetration resistance is covered in Section 5.2.3.

- Determine sample recovery/sample length as shown. Measure the total length of sample recovered from the split-spoon sampler, including material in the drive shoe. Do not include cuttings or wash material that may be in the upper portion of the sample tube.

- Indicate any change in lithology by drawing a line at the appropriate depth. For example, if clayey silt was encountered from 0 to 5.5 feet and shale from 5.5 to 6.0 feet, a line shall be drawn at this increment. This information is helpful in the construction of cross-sections. As an alternative, symbols may be used to identify each change in lithology.

- The density of granular soils is obtained by adding the number of blows for the last two increments. Refer to Density of Granular Soils Chart on back of log sheet. For consistency of cohesive soils refer also to the back of log sheet - Consistency of Cohesive Soils. Enter this information under the appropriate column. Refer to Section 5.2.3.

FIGURE 5
COMPLETED BORING LOG (EXAMPLE)

BORING LOG

Page 1 of 1

PROJECT NAME: NSB- SITE
PROJECT NUMBER: 9594
DRILLING COMPANY: SOILTEST CO.
DRILLING RIG: CME-55
BORING NUMBER: SB/MW 1
DATE: 3/8/96
GEOLOGIST: SJ CONTI
DRILLER: R. ROCK

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
S-1 @ 0800	0.0	7/6	1.5/2.0		M DENSE	BRN TO BLK	SILTY SAND - SOME	SM	MOIST SL. ORG. ODOR	5	0	0	0
	2.0	9/10					ROCK FR: TR BRICKS (FILL)		FILL TO 4'±				
	4.0			4.0									
S-2 @ 0810	6.0	5/7	2.0/2.0		M DENSE	BRN	SILTY SAND - TR FINE GRAVEL	SM	MOIST - W ODOR NAT. MATL. TOOK SAMPLE SB01-0406 FOR ANALYSIS	10	0	-	-
	•	9/8		7' ▽									
	8.0			8.0									
S-3 @ 0820	10.0	6/8	1.9/2.0		DENSE	TAN BRN	FINE TO COARSE SAND TR. F. GRAVEL	SW	WET HIT WATER: 7'±	0	0	0	0
	12.0	17/16		12.0									
S-4 @ 0830	14.0	7/6 5/8	1.6/2.0		STIFF	GRAY	SILTY CLAY	CL	MOIST → WET	0	.5	-	-
	15.0			15.0					AUGER REF @ 15'				
9/5	①		4.0/5.0	16	M HARD	BRN	SILTSTONE	VBR	WEATHERED LO ✱ JNTS @ 15.5 WATER STAINS @ 16.5, 17.1, 17.5	0	0	0	0
				19'					LOSING SOME				
	20.0				HARD	GRAY	SANDSTONE - SOME SILTSTONE	BR	DRILL H2O @ 17'± SET TEMP 6" CAS TO 15.5				
4.0/5.0	②		5.0/5.0						SET 2"Φ PVC SCREEN 16-25	0	0	0	0
									SAND 14-25				
	25.0			25					PELLETS 12-14				

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated response read.

• 1-20Z 1-80Z

Drilling Area Background (ppm): 0

Remarks: CME-55 R16, 4¼" ID HSA - 9" OD ±
2" SPLIT SPOONS - 140 LB HAMMER - 30" DROP
NX CORE IN BEDROCK RUN ① = 25 min, RUN ② = 15 min

Converted to Well: Yes ✓ No _____ Well I.D. #: MW-1

- Enter color of the material in the appropriate column.

- Describe material using the USCS. Limit this column for sample description only. The predominant material is described last. If the primary soil is silt but has fines (clay) - use clayey silt. Limit soil descriptors to the following:

  - Trace: 0 - 10 percent
  - Some: 11 - 30 percent
  - And/Or: 31 - 50 percent

- Also indicate under Material Classification if the material is fill or natural soils. Indicate roots, organic material, etc.

- Enter USCS symbol - use chart on back of boring log as a guide. If the soils fall into one of two basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example ML/CL or SM/SP.

- The following information shall be entered under the "Remarks" column and shall include, but is not limited by, the following:

  - Moisture - estimate moisture content using the following terms - dry, moist, wet and saturated. These terms are determined by the individual. Whatever method is used to determine moisture, be consistent throughout the log.

  - Angularity - describe angularity of coarse grained particles using the terms angular, subangular, subrounded, or rounded. Refer to ASTM D 2488 or Earth Manual for criteria for these terms.

  - Particle shape - flat, elongated, or flat and elongated.

  - Maximum particle size or dimension.

  - Water level observations.

  - Reaction with HCl - none, weak, or strong.

- Additional comments:

  - Indicate presence of mica, caving of hole, when water was encountered, difficulty in drilling, loss or gain of water.

  - Indicate odor and Photoionization Detector (PID) or Flame Ionization Detector (FID) reading if applicable.

  - Indicate any change in lithology by drawing a line through the lithology change column and indicate the depth. This will help when cross-sections are subsequently constructed.

  - At the bottom of the page indicate type of rig, drilling method, hammer size and drop, and any other useful information (i.e., borehole size, casing set, changes in drilling method).

- Vertical lines shall be drawn (as shown in Figure 5) in columns 6 to 8 from the bottom of each sample to the top of the next sample to indicate consistency of material from sample to sample, if the material is consistent. Horizontal lines shall be drawn if there is a change in lithology, then vertical lines drawn to that point.

- Indicate screened interval of well, as needed, in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.2 Rock Classification

- Indicate depth at which coring began by drawing a line at the appropriate depth. Indicate core run depths by drawing coring run lines (as shown) under the first and fourth columns on the log sheet. Indicate RQD, core run number, RQD percent, and core recovery under the appropriate columns.

- Indicate lithology change by drawing a line at the appropriate depth as explained in Section 5.5.1.

- Rock hardness is entered under designated column using terms as described on the back of the log or as explained earlier in this section.

- Enter color as determined while the core sample is wet; if the sample is cored by air, the core shall be scraped clean prior to describing color.

- Enter rock type based on sedimentary, igneous or metamorphic. For sedimentary rocks use terms as described in Section 5.3. Again, be consistent in classification. Use modifiers and additional terms as needed. For igneous and metamorphic rock types use terms as described in Sections 5.3.8.

- Enter brokenness of rock or degree of fracturing under the appropriate column using symbols VBR, BR, BL, or M as explained in Section 5.3.5 and as noted on the back of the Boring Log.

- The following information shall be entered under the remarks column. Items shall include but are not limited to the following:

  - Indicate depths of joints, fractures and breaks and also approximate to horizontal angle (such as high, low), i.e., 70° angle from horizontal, high angle.
  - Indicate calcareous zones, description of any cavities or vugs.
  - Indicate any loss or gain of drill water.
  - Indicate drop of drill tools or change in color of drill water.

- Remarks at the bottom of Boring Log shall include:

  - Type and size of core obtained.
  - Depth casing was set.
  - Type of rig used.

- As a final check the boring log shall include the following:

  - Vertical lines shall be drawn as explained for soil classification to indicate consistency of bedrock material.

  - If applicable, indicate screened interval in the lithology column. Show top and bottom of screen. Other details of well construction are provided on the well construction forms.

5.5.3 Classification of Soil and Rock from Drill Cuttings

The previous sections describe procedures for classifying soil and rock samples when cores are obtained. However, some drilling methods (air/mud rotary) may require classification and borehole logging based on identifying drill cuttings removed from the borehole. Such cuttings provide only general information on subsurface lithology. Some procedures that shall be followed when logging cuttings are:

- Obtain cutting samples at approximately 5-foot intervals, sieve the cuttings (if mud rotary drilling) to obtain a cleaner sample, place the sample into a small sample bottle or "zip lock" bag for future reference, and label the jar or bag (i.e. hole number, depth, date, etc.). Cuttings shall be closely examined to determine general lithology.
- Note any change in color of drilling fluid or cuttings, to estimate changes in lithology.
- Note drop or chattering of drilling tools or a change in the rate of drilling, to determine fracture locations or lithologic changes.
- Observe loss or gain of drilling fluids or air (if air rotary methods are used), to identify potential fracture zones.
- Record this and any other useful information onto the boring log as provided in Figure 1.

This logging provides a general description of subsurface lithology and adequate information can be obtained through careful observation of the drilling process. It is recommended that split-barrel and rock core sampling methods be used at selected boring locations during the field investigation to provide detailed information to supplement the less detailed data generated through borings drilled using air/mud rotary methods.

5.6 Review

Upon completion of the borings logs, copies shall be made and reviewed. Items to be reviewed include:

- Checking for consistency of all logs.
- Checking for conformance to the guideline.
- Checking to see that all information is entered in their respective columns and spaces.

6.0 REFERENCES

Unified Soil Classification System (USCS).

ASTM D2488, 1985.

Earth Manual, U.S. Department of the Interior, 1974.

7.0 RECORDS

Originals of the boring logs shall be retained in the project files.

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1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment , chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

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

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities

- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:

  - Well removed from pedestrian/vehicle thoroughfares.

  - Avoidance of areas where control/custody cannot be maintained.

  - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.

  - Avoidance of potentially contaminated areas.

  - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

  The selected decontamination site should include the following, where possible:

  - Areas where potable water and electricity are provided.

> ***Safety Reminder***
>
> When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:
>
> - All power is routed through a Ground Fault Circuit Interrupter (GFCI).
>
> - All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.
>
> In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.

- Areas that offer sufficient size to carry out the specific decontamination sequence.

- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.

  - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.

  - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.

  - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.

  - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:

  - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

- Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.

- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.

2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.

3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.

4. Remove the pump and tubing/bailer from the container

5. Rinse external pump components using tap water.

6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents –
> Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.

8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.

9. Drain residual deionized water to the extent possible.

10. Allow components of the equipment to air dry.

11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.

12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

> ***SAFETY REMINDER***
> Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

> ***NOTE***
> In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.

- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:

  1. Wash with soap and water
  2. Rinse with tap water
  3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

> ***CAUTION***
> Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

> ***CAUTION***
> In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol

5. To the extent possible, allow components to air dry.

6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.

7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 ˚F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0˚ tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40˚ fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.

2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.

3. Always wear PPE as specified in the HASP such as:

   - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.

4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.

5. Do not modify equipment unless the manufacturer has approved the modifications.

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.

3. Rinse the equipment with tap water.

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.

5. Rinse the equipment with deionized water.

6. To the extent possible, allow components to air dry.

7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.

8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device

- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.

- Extract the dredge and wash it in soap and water per the project-specific planning documents.

> ***CAUTION***
> When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

NOTE
Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE
Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).

4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:

   - Enclose areas accessible by the general public using construction fencing and signs.

   - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.

   - Maintain the retaining bolt and label on the outside of storage containers where readily visible.

   - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.

   - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.

   - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 Decontamination Evaluation

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.

- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:

  - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.

  - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.

  - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:

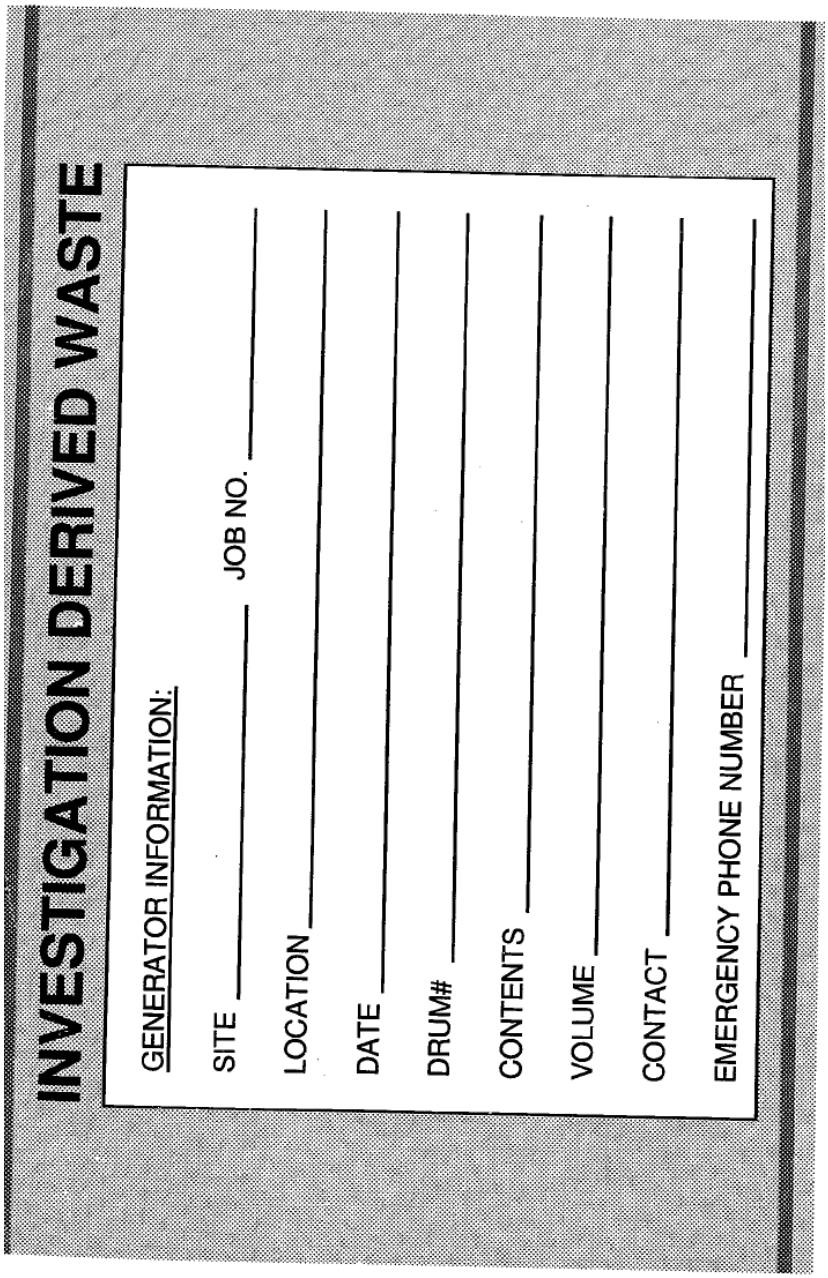
    - Per decontamination method
    - Per disposable article/batch number of disposable articles

NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.

Attachment A
iDW Label



STANDARD OPERATING PROCEDURE
NUMBER SOP-05

INCREMENTAL SAMPLING METHODOLOGY (ISM) FOR SOIL AND/OR SEDIMENT FOR THE MILITARY MUNITIONS RESPONSE PROGRAM

1.0 PURPOSE

This Standard Operating Procedure (SOP) establishes the procedure for collecting incremental sampling methodology (ISM) surface soil and/or sediment samples using a hand operated coring device to support the field investigations. This SOP is compliant with United States Environmental Protection Agency (USEPA) SW-846 Method 8330B, Appendix A, and United States Army Corps of Engineers (USACE) guidance documents.

The most widely known description of ISM for environmental use is SW-846 Method 8330B, Appendix A. The specific sample collection and processing procedures described in Method 8330B were based primarily on studies by the USACE Cold Regions Research and Engineering Laboratory (CRREL). These studies were designed to demonstrate and develop the methodology for application to the investigation of explosive compounds at active military testing and training ranges.

This technique will assist in estimating mean munitions constituent (MC) concentrations which can be used to assess whether potential MC:

- Are present within the sampled area at an average concentration greater than the analytical method detection limit or reporting limit;
- May pose an unacceptable risk to human health, or ecological receptors;
- May contribute to significant contaminant concentrations to groundwater; and
- Concentrations exceed mean background or ambient concentrations unrelated to munitions activities.

A Sampling Unit (sometimes synonymous with a Decision Unit) is the area and depth of soil to be represented by the ISM samples. Sampling Units must be delineated so that the mean analyte concentrations obtained are directly relevant to well defined project objectives. Typical Sampling Units could be as small as 3 feet by 3 feet or as large as 300 feet by 300 feet. For this project, in general, Sample Units are smaller than decision units and several sampling units were selected for each decision unit based on a site wide grid layout with grids 100 feet by 100 feet (Figure 11-1). For example DU2 is 300 feet long by 300 feet wide and contains nine 100 feet by 100 feet sampling units. The only exception

is DU1, which contains two sampling units; the first from 0 to 3 inches below ground surface across the inner face of the existing berm and 3 to 18 inches below the inner face of the existing berm.

2.0 REQUIRED FIELD FORMS AND EQUIPMENT

The following field forms and equipment are required for ISM soil and/or sediment sampling.

Disposable medical-grade gloves (e.g., latex, nitrile)

Indelible marker

CRREL coring device (or equivalent), with properly sized CRREL coring shoe (size predetermined before sampling commences, based on number of increments, sample depth interval, and required sample size)

Plastic storage bags

Sample tags

Shipping containers (containing ice)

Sample containers: Sample containers are certified clean by the laboratory supplying the containers.

Field Forms: Soil and Sediment Sample Log (SOP-06)

Electronic label maker

3.0 SAMPLING PROCEDURES

Hand coring will be employed to collect incremental soil cores of cohesive soils and/or sediments using a coring device and properly-sized coring shoe (or equivalent). This will ensure that increments of soil or sediment are collected in a consistent manner from across the entire Sampling Unit. This consistency maximizes the representativeness of the ISM sample. Although the use of a hand trowel or hand auger may be unavoidable for some material, such tools are not recommended because they do not control the amount of material per increment and uniform increments are critical to ISM. If the soils and/or sediments are not cohesive, this SOP should not be used and an alternate procedure should be followed that ensures a representative sampling scheme that is appropriate for the situation at hand.

Practical limitations and unforeseen field conditions may require modifying the delineation of Sampling Units as defined during planning. Conditions of this nature may include the presence of pavement, buildings, or exposed bedrock surface without soil. In general, significantly changing the total sampling area should be avoided if possible. Specifically for Site 12, a former EOD area, the practice of anomaly avoidance is required on site during all sampling events and will dictate the allowable increment sample locations. If a subsurface anomaly is identified a sample location will be moved to the nearest area clear of subsurface anomalies and a sample collected. In addition, sampling soil from one habitat type is

preferred, for Site 12 all samples should be representative (i.e. collected) from terrestrial habitat (soil) and not wetlands (sediment) within a sampling unit. Changes to grab locations and their rationale should be noted on the sample sheet or in the field book. Changes to sampling or decision units and their rationale should be discussed with the Tetra Tech Project Manager, approved, and fully described in field task modification requests (FTMRs) and project reports.

A 1 to 2 kilogram (dry weight) ISM sample usually ensures that sufficient ISM mass has been collected to adequately represent the Sampling Unit mean concentration. An adjustment is necessary to incorporate project-specific soil densities and moisture contents (if known) into the determination for the proper volume of increments needed in order to meet this target mass requirement, where 1 kilogram (dry weight) represents a minimum requirement and 2 kilograms (dry weight) represents a recommended maximum amount for each ISM sample. Note, if the recommended core barrel size, per the table below, is not available, multiple adjacent plugs (increments) may be collected using a smaller size core to enable collection of the appropriate increment volume from each increment location.

The sampler will wear clean, disposable, medical-grade gloves and the coring device will be decontaminated between Sampling Units.

3.1 INCREMENT SAMPLING PROCEDURES

3.1.1 The correct size coring shoe (or equivalent) was determined based on the number of sample increments required, the sampling depth, and the average density of the soil or sediment. Since a 1 to 2 kilogram (dry weight) ISM sample is preferred, the following table matches the project-specific need to the correct coring shoe size (or equivalent auger diameter and depth).

Coring Device Size Selection Based on Number of Increments and Sample Depth

Number of Increments	Sample Depth (inches)	Soil Density* (g/cc)	Minimum Corer Diameter - 1,000 grams total (nearest ¼ inch)	Maximum Corer Diameter - 2,000 grams total (nearest ¼ inch)
10	3	1.5	6.52	9.22
30	3	1.5	3.76	5.32
30	15	1.5	1.68	2.38
50	3	1.5	2.91	4.12
120	3	1.5	1.88	2.66
150	3	1.5	1.68	2.38

* Assumed soil density = 1.50 grams per cubic centimeter (g/cc) and assumed percent moisture is less than 10 percent. At the discretion of the Tetra Tech FOL, the coring device size may be adjusted based on site conditions that differ from these assumptions, but must be the same throughout the entire Sampling Unit.

3.1.2 Grid off the Sampling Unit into increments of equal size based on the number listed in the SAP for each decision unit/sampling unit (e.g. for a 100 foot by 100 foot grid, 5 squares wide by 5 squares long, resulting in each grid cell being 20 feet wide and 20 feet long). Stakes, flagging, or other means of clear visual reference should be used so the field sampler can accurately identify each grid.

3.1.3 A systematic-random sampling design will be used when collecting individual increments to build each sample. The starting location is chosen randomly and the remaining sampling locations are laid out in a regular pattern. Starting in one cell (a corner cell is recommended), systematically sample each grid cell as described in Steps 3.1.3.1 through 3.1.3.4. A successful systematic increment collection scheme is to start in one corner of the Sampling Unit and collect an increment of surface soil after a predetermined number of steps or predetermined distance based on the decision and sample unit size. Then work in a back-and-forth path a systematic manner, traveling to each successive cell until an increment has been collected from each grid cell. Figure 1 is an example of a 100-increment sample unit. For Site 12, Figures 14-1 through 14-6 depicted the systematic random sampling and replicate design for each Site 12 decision unit.

3.1.3.1 Upon entering a grid cell, locate the first systematic random sample location for that grid cell from which to obtain an increment. Clear the area to be sampled for subsurface anomalies and of any surface debris (herbaceous vegetation, twigs, rocks, litter, etc.).

3.1.3.2 Turn the coring device into the ground to the depth of the selected shoe. Remove the coring device and visually verify that the entire core was retained. If the coring device is not filled with soil, collect remaining soil from the hole to fill the coring device with the intended soil volume.

3.1.3.3 Eject the soil increment into a labeled sample container such as a plastic bag, 2-liter wide-mouth container, or other suitable container which must be large enough to hold all of the increments to be collected from the Sampling Unit.

3.1.3.4 For Site 12, field replicate samples will be collected at all decision units in order to provide precision data that will be used to support the data evaluation process. Field replicates for ISM are not field split samples; rather, they must be independently collected incremental samples from the same Sampling Unit. This will be accomplished by collecting the first replicate at each interval from approximately 2 to 3 feet away from the original increment as shown on Figures 14-1 through 14-6.

3.1.4 Repeat steps 3.1.3.1 to 3.1.3.4 in the designated Sampling Unit until the entire sample grid has been collected.

3.1.5 For each of the replicate ISM samples, package the entire lot of collected soil or sediment and send to the laboratory for processing and analysis.

3.1.6 Complete the required information on the Chain of custody form noting that for all ISM samples at Site 12 indicate that the volume of sample required for metals analysis should be removed by the laboratory prior to grinding the sample. Also, complete the Soil and Sediment Sample Log Sheet (an example is attached at the end of this SOP). Note the location of each increment in the “OBSERVATIONS/NOTES” section of the Soil and Sediment Sample Log Sheet.

3.1.7 Decontaminate the coring device in the field between each ISM Sampling Unit.

4.0 REFERENCES

GPL Laboratories, LLC, 2009. SOP No. G.22: General Laboratory Multi Incremental Sampling (MIS) sub-sampling procedure. January.

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US Army Corps of Engineers (USACE), 2004. Field Sampling Tools for Explosives Residues Developed at CRREL. ERDC/CRREL TN-04-1. April.

USACE. 2007, Protocols for Collection of Surface Soil Samples at Military Training and Testing Ranges for the Characterization of Energetic Munitions Constituents. ERDC/CRREL TR-07-10. July.

USACE, 2009. Interim Guidance 09-02: Implementation of Incremental Sampling (IS) of Soil for the Military Munitions Response Program. July.

United States Environmental Protection Agency (USEPA), 2006. SW-846 Method 8330B, Appendix A. Office of Solid Waste and Emergency Response, Washington, DC. October.

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5.0 ATTACHMENTS

1. Soil and Sediment Sample Log Sheet

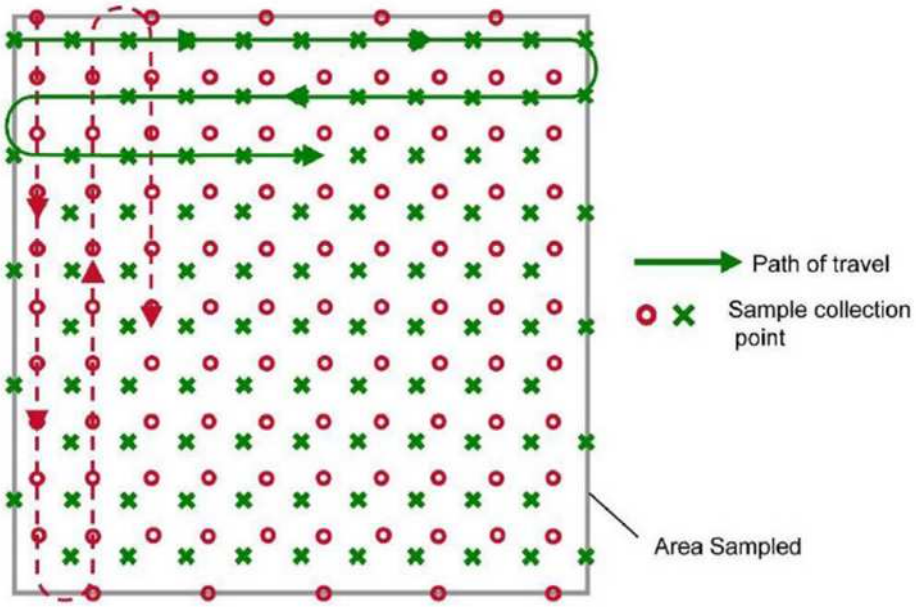

Figure 1. An example of systematic random sample for one ISM sample and one replicate. Additional replicates would be collected by selecting a unique starting location and following the same sample spacing pattern. Note the path of travel for each replicate and alternate the path of travel for each sample.

Modified from Figure 5 From ERDC/CRREL TR-07-10 (Hewitt et.al, 2007).

ATTACHMENT 1

SOIL AND SEDIMENT SAMPLE LOG SHEET

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth Interval	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes procedures and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing or for offsite laboratory analysis.

2.0 SCOPE

The information presented in this document is applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

3.0 GLOSSARY

Analyte – Chemical or radiochemical material whose concentration, activity, or mass is measured.

Composite Sample – A sample representing a physical average of grab samples.

Environmental Sample – A quantity of material collected in support of an environmental investigation that does not require special handling or transport considerations as detailed in SOP SA-6.1.

Grab Sample – A portion of material collected to represent material or conditions present at a single unit of space and time.

Hazardous Waste Sample – A sample containing (or suspected to contain) concentrations of contaminants that are high enough to require special handling and/or transport considerations per SOP SA-6.1.

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

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of soil samples. The Project Manager also has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel in accordance with applicable planning documents.

Field Operations Leader - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field

technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface water and sediment samples. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

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

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

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

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

5.0 HEALTH AND SAFETY

Precautions to preserve the health and safety of field personnel implementing this SOP are distributed throughout. The following general hazards may also exist during field activities, and the means of avoiding them must be used to preserve the health and safety of field personnel:

Bridge/Boat Sampling – Potential hazards associated with this activity include:

- Traffic – one of the primary concerns as samplers move across a bridge because free space of travel is not often provided. Control measures should include:
  - When sampling from a bridge, if the samplers do not have at least 6 feet of free travel space or physical barriers separating them and the traffic patterns, the HASP will include a Traffic Control Plan.
  - The use of warning signs and high-visibility vests are required to warn oncoming traffic and to increase the visibility of sample personnel.
- Slips, trips, and falls from elevated surfaces are a primary concern. Fall protection shall be worn when or if samplers must lean over a rail to obtain sample material. A Fall Protection Competent Person (in accordance with Occupational safety and Health Administration [OSHA] fall protection standards) must be assigned to ensure that fall protection is appropriately and effectively employed

- Water hazards/drowning – if someone enters the water from an elevated surface (such as a bridge or dock) and when sampling from a boat. To minimize this potential, personnel shall wear United states Coast Guard (USCG)-approved floatation devices, and the sampling crew must also have on hand a Type IV Throwable Personal Floatation Device with at least 90 feet of 3/8-inch rope. See Section 5.5.2 of this SOP.

- Within the HASP, provisions will also be provided concerning the requirement of a Safe Vessel Certification or the necessity to conduct a boat inspection prior to use. In addition, the HASP shall also specify requirements as to whether the operator must be certified as a commercial boat operator and whether members of the sampling team must have a state-specific safe boating certification.

Entering Water to Collect Samples – Several hazards are associated with this activity and can be mitigated as follows:

- Personnel must wear a USCG-approved Floatation Device (selected and identified in the HASP). The SSO shall ensure that the device selected is in acceptable condition and suitable for the individual using it. This includes consideration of the weight of the individual.

- Lifelines shall be employed from a point on the shore. This activity will always be conducted with a Buddy. See Section 6.5.2.

- Personnel shall carry a probe to monitor the bottom ahead of them for drop offs or other associated hazards.

- The person in the water shall exercise caution concerning the path traveled so that the lifeline does not become entangled in underwater obstructions such as logs, branches, stumps, etc., thereby restricting its effectiveness in extracting the person from the water.

- Personnel shall not enter waters on foot in situations where natural hazards including alligators, snakes, as well as sharks, gars, and other predators within inland waterways may exist.

- In all cases, working along and/or entering the water during high currents or flood conditions shall be prohibited.

- Personnel shall not enter bodies of water where known debris exists that could result in injuries from cuts and lacerations.

Sampling in marshes or tidal areas in some instances can be accomplished using an all-terrain vehicle (ATV). This is not the primary recommended approach because the vehicle may become disabled, or weather conditions or tidal changes could result in environmental damage as well as loss of the vehicle. The primary approach is recommended to be on foot where minimal disturbance would occur. The same precautions specified above with regard to sediment disturbance apply as well as the previously described safety concerns associated with natural hazards. The natural hazards include alligators, bees (nests in dead falls and tree trunks), snakes, etc. In addition, moving through and over this terrain is difficult and could result in muscle strain and slips, trips, and falls. Common sense dictates that the sampler selects the most open accessible route over moderate terrain. Move slowly and deliberately through challenging terrain to minimize falls. Mud boots or other supportive PPE should be considered and specified in the HASP to permit samplers to move over soft terrain with the least amount of effort. In these situations, it is also recommended, as the terrain allows, that supplies be loaded and transported in a sled over the soft ground.

Working in these areas, also recognize the following hazards and means of protection against them:

Insects are also a primary concern. These include mosquitoes, ticks, spiders, bees, ants, etc. The HASP will identify those particular to your area. Typical preventative measures include:

- Use insect repellant. Approval of various repellants should be approved by the Project Chemist or Project Manager.
- Wearing light-colored clothing to control heat load due to excessive temperatures. In addition, it makes it easier to detect crawling insects on your clothing.
- Taping pants to boots to deny access. Again, this is recommended to control access to the skin by crawling insects. Consultation with the Project Health and Safety Officer SSO/Health and Safety Manager is recommended under extreme heat loads because this will create conditions of heat stress.
- Performing a body check to remove insects. The quicker you remove ticks, the less likely they will become attached and transfer bacteria to your bloodstream. Have your Buddy check areas inaccessible to yourself. This includes areas such as the upper back and between shoulder blades where it is difficult for you to examine and even more difficult for you to remove.

Safety Reminder

If you are allergic to bee or ant stings, it is especially critical that you carry your doctor-recommended antidote with you in these remote sampling locations due to the extended time required to extract incapacitated individuals as well as the effort required to extract them. In these scenarios, instruct your Buddy in the proper administration of the antidote. In all cases, if you have received a sting, administer the antidote regardless of the immediate reaction, evacuate, and seek medical attention as necessary. The FOL and/or SSO will determine when and if you may return to the field based on the extent of the immune response and hazards or potential hazards identified in these locations. To the FOL and SSO, this is a serious decision you have to make as to whether to take someone vulnerable to these hazards into a remote location where you may not be able to carry them out. Consider it wisely.

Poisonous Plants – To minimize the potential of encountering poisonous plants in the field, at least one member of the field team needs to have basic knowledge of what these plants look like so that they can be recognized, pointed out to other field personnel, and avoided if at all possible. If the field team cannot avoid contact and must move through an area where these plants exist, the level of personal protective equipment (PPE) shall include Tyvek coveralls and enhanced decontamination procedures for the removal of oils from the tooling and/or equipment.

Temperature-Related Stress – Excessively cold temperatures may result in cold stress, especially when entering the water either intentionally or by accident. Provisions for combating this hazard should be maintained at the sample location during this activity. Excessively hot temperatures may result in heat stress especially in scenarios where equipment is packed through the marsh.

Because all of these activities are conducted outside, electrical storms are a significant concern. The following measures will be incorporated to minimize this hazard:

- Where possible, utilize commercial warning systems and weather alerts to detect storms moving into the area.

- If on or in the water, get out of the water. Move to vehicles or preferably into enclosed buildings with plumbing and wiring.

- Where warning systems are not available, follow the 30/30 Rule (i*f there are less than 30 seconds between thunder and lightning, go inside for at least 30 minutes after the last thunder).*

See Section 4.0 of the Health and Safety Guidance Manual (HSGM) for additional protective measures.

6.0 PROCEDURES

6.1 Introduction

Collecting a representative sample of surface water or sediment may be difficult because of water movement, stratification, or heterogeneous distribution of the targeted analytes. To collect representative samples, one must standardize sampling methods related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples. Consult Appendix C for guidance on sampling that should be considered during project planning and that may be helpful to field personnel.

6.1.1 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. In general, the most representative samples are obtained from mid-channel at a stream depth of 0.5 foot in a well-mixed stream; however, project-specific planning documents will address site-specific sampling requirements including sample collection points and sampling equipment. The most frequently used samplers include the following:

- ~~Peristaltic pump~~
- ~~Bailer~~
- ~~Dip sampler~~
- ~~Weighted bottle~~
- ~~Hand pump~~
- Kemmerer
- Depth-integrating sampler

~~The dip sampler and weighted bottle sampler are used most often, and detailed discussions for these devices and the Kemmerer sampler are addressed subsequently in this section.~~

~~The criteria for selecting a sampler include:~~

1. ~~Disposability and/or easy decontamination.~~

2. ~~Inexpensive cost (if the item is to be disposed).~~

3. ~~Ease of operation.~~

4. ~~Non-reactive/non-contaminating properties - Teflon-coated, glass, stainless-steel or polyvinyl chloride (PVC) sample chambers are preferred (in that order).~~

Measurements collected for each sample (grab or each aliquot collected for compositing) shall include but not be limited to:

- Specific conductance
- Temperature
- pH
- Dissolved oxygen

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample log sheets (see Attachment A) or an equivalent electronic form(s). These analyses may be selected to provide information on water mixing/stratification and potential contamination. Various types of water bodies have differing potentials for mixing and stratification.

In general, the following equipment if necessary for obtaining surface water samples:

- Required sampling equipment, which may include a remote sampling pole, weighted bottle sampler, Kemmerer sampler, or other device.

- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.

- Required PPE as directed in the project-specific planning document, which may include:

  - Nitrile surgeon's or latex gloves (layered as necessary).

  - Safety glasses.

  - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

> ***Safety Reminder***
> The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

  - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).

  - Required decontamination equipment.

  - Required sample containers.

  - Sealable polyethylene bags (e.g., Ziploc® baggies).

  - Heavy-duty cooler.

  - Ice.

  - Paper towels and garbage bags.

  - Chain-of-custody records and custody seals.

~~Dip Sampling~~

~~Specific procedures for collecting a dip or grab sample of surface water can vary based on site-specific conditions (e.g., conditions near the shore and how closely a sampler can safely get to the shore). The general procedure for collecting a sample using a pole or directly from the water body is as follows:~~

1. ~~If using a remote sampling pole, securely attach the appropriate sample container to a pole of sufficient length to reach the water to be sampled. Samples for volatile analysis should be collected first. Use PPE as described in the HASP. When sample containers are provided pre-preserved or if the pole cannot accommodate a particular sample container, use a dedicated, clean, unpreserved bottle/container for sampling and transfer to an appropriately preserved container.~~

2. ~~Remove the cap. Do not place the cap on the ground or elsewhere where it might become contaminated.~~

3. ~~Carefully dip the container into the water just below the surface (or as directed by project-specific planning documents), and allow the bottle to fill. Sample bottles for volatile analysis must be filled with no headspace. Avoid contacting the bottom of the water body because this will disturb sediment that may interfere with the surface water sample.~~

4. ~~Retrieve the container and carefully replace the cap securely. If using a container other than the sample bottle, pour the water from that container into the sample bottle and replace the cap securely.~~

5. ~~Use a clean paper towel to clean and dry the outside of the container.~~

6. ~~Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.~~

7. ~~Proceed with the handling and processing of each sample container as described in SOP SA-6.2.~~

~~Constituents measured in grab samples collected near the water surface are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration distributed throughout the water column and in the cross section. Therefore, as possible based on site conditions, the sampler may be required to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.~~

CAUTION

In areas prone to natural hazards such as alligators and snakes, etc., always use a buddy as a watch. Always have and use a lifeline or throwable device to extract persons who could potentially fall into the water. Be attentive to the signs, possible mounds indicating nests, and possible slides into the water. Remember that although snakes are typically encountered on the ground, it is not unheard of to see them on low-hanging branches. Be attentive to your surroundings because these may indicate that hazards are nearby.

~~Weighted Bottle Sampling~~

~~A grab sample can also be collected using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open~~

~~bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.~~

~~A closed weighted bottle sampler consists of glass or plastic bottle with a stopper, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The general procedure for sampling with this device is as follows:~~

1. ~~Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).~~

2. ~~When the desired depth is reached, pull out the stopper with a sharp jerk of the stopper line.~~

3. ~~Allow the bottle to fill completely, as evidenced by the absence of air bubbles.~~

4. ~~Raise the sampler and cap the bottle.~~

5. ~~Use a paper towel to clean and dry the outside of the container. This bottle can be used as the sample container as long as the bottle is an approved container type.~~

6. ~~Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.~~

7. ~~Proceed with the handling and processing of each sample container as described in SOP SA-6.2.~~

Kemmerer Sampler

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon-coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while it is lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth.

2. When the desired depth is reached, send down the messenger to close the cylinder and then raise the sampler.

3. Open the sampler valve to fill each sample bottle (filling bottles for volatile analysis first).

4. Use a paper towel to clean and dry the outside of the container.

5. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

6. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

6.1.2 Surface Water Sampling Techniques

Samples collected during site investigations may be grab samples or composite samples. The following general procedures apply to various types of surface water collection techniques:

- If a clean, pre-preserved sample container is not used, rinse the sample container least once with the water to be sampled before the sample is collected. This is not applicable when sample containers are provided pre-preserved because doing so will wash some or all of the preservative out of the bottle.

- For sampling moving water, collect the farthest downstream sample first, and continue sample collection in an upstream direction. In general, work from zones suspected of low contamination to zones of high contamination.

- Take care to avoid excessive agitation of the water because loss of volatile constituents could result.

- When obtaining samples in 40 mL vials with septum-lined lids for volatile organics analysis, fill the container completely (with a meniscus) to exclude any air space in the top of the bottle and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. Turn the vial upside down and tap gently on your wrist to check for air bubbles. If air bubbles rise in the bottle, add additional sample volume to the container.

- Do not sample at the surface, unless sampling specifically for a known constituent that is immiscible and on top of the water. Instead, invert the sample container, lower it to the approximate depth, and hold it at about a 45-degree angle with the mouth of the bottle facing upstream.

6.2 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

6.3 Sediment Sampling

6.3.1 General

If composite surface water samples are collected, sediment samples are usually collected at the same locations as the associated surface water samples. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body, in a depositional area if possible based on sample location restraints (see below), unless the SAP states otherwise.

Generally, coarser-grained sediments are deposited near the headwaters of reservoirs. Bed sediments near the center of a water body will be composed of fine-grained materials that may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathymetry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled, in general, and areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials shall be generally avoided. Follow instructions in the SAP, as applicable.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are less than detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

Samples collected for volatile organic compound (VOC) analysis must be collected prior to any sample homogenization. Regardless of the method used for collection, the aliquot for VOC analysis must be collected directly from the sampling device (hand auger bucket, scoop, trowel), to the extent practical. If a device such as a dredge is used, the aliquot should be collected after the sample is placed in the mixing container prior to mixing.

In some cases, the sediment may be soft and not lend itself to collection by plunging Encore™ or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sampling device, (Encore™ barrel or syringe) prior to sample collection, and carefully place the sediment in the device, filling it fully with the required volume of sample.

On active or former military sites, ordnance items may be encountered in some work areas. Care should be exercised when handling site media (such as if unloading a dredge as these materials may be scooped up). If suspected ordnance items are encountered, stop work immediately, move to shore and notify the Project Manager and Health and Safety Manager.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3 and Attachment B or an equivalent electronic form.

6.3.2 Sampling Equipment and Techniques for Bottom Materials

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

SAFETY REMINDER

The following health and safety provisions apply when working on/over/near water:

- At least two people are required to be present at the sampling location in situations where the water depth and/or movement deem it necessary, each wearing a USCG-approved Personal Flotation Devices

- A minimum of three people are required if *any* of the following conditions are anticipated or observed:

  - Work in a waterway that is turbulent *or* swift that could sweep a sampler down stream should he or she fall in accidentally.

  - The underwater walking surface (e.g., stream/river bed) is suspected or observed to involve conditions that increase the potential for a worker to fall into the water. Examples include large/uneven rocks or boulders, dense mud or sediment that could entrap worker's feet, etc.

  - Waterway is tidal, and conditions such as those listed above could rapidly change.

The third person in the above condition must be equipped and prepared to render emergency support [e.g., lifeline, tethered Personal Flotation Device (Throwable Type IV, life saver), skiff, means to contact external emergency response support, etc.]

The following samplers may be used to collect sediment samples:

- ~~Scoop sampler~~
- ~~Dredge samplers~~
- Coring samplers

Each type of sampler is discussed below.

In general, the following equipment if necessary for obtaining sediment samples:

- Required sampling equipment, which may include a scoop sampler, dredge sampler, coring sampler, or stainless steel or pre-cleaned disposable trowel.
- Stainless bowl or pre-cleaned disposable bowl to homogenize sample.
- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.
- Required PPE as directed in the project-specific planning document, which may include:
  - Nitrile surgeon's or latex gloves (layered as necessary).
  - Safety glasses.
  - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.
  - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).
  - Required decontamination equipment.
  - Required sample containers.
  - Sealable polyethylene bags (e.g., Ziploc® baggies).
  - Heavy-duty cooler.
  - Ice.
  - Paper towels and garbage bags.
  - Chain-of-custody records and custody seals.

~~Scoop Sampler~~

~~A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.~~

~~If the water body can be sampled from the shore or if the sampler can safely wade to the required location, the easiest and best way to collect a sediment sample is to use a scoop sampler. Scoop sampling also reduces the potential for cross-contamination. The general scoop sampling procedure is as follows:~~

1. ~~Reach over or wade into the water body.~~

2. ~~While facing upstream (into the current), scoop the sampler along the bottom in an upstream direction. Although it is very difficult not to disturb fine-grained materials at the sediment-water interface when using this method, try to keep disturbances to a minimum.~~

Dredge Samplers

Dredges are generally used to sample sediments that cannot easily be obtained using coring devices (e.g., coarse-grained or partially cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger." Some dredges are heavy and may require use of a winch and crane assembly for sample retrieval. The three major types of dredges are Peterson, Eckman and Ponar.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The general procedure for using dredge samplers is as follows:

1. Gently lower the dredge to the desired depth.

2. When the desired depth is reached, send the messenger down to cable to close the cylinder and then carefully raise the sampler.

3. Open the sampler to retrieve the sediment.

4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis *prior to* homogenization. Homogenize the remainder of the sediment collected.

5. Fill the containers for all analyses other and VOCs.

6. Use a paper towel to clean and dry the outside of each container.

7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

SAFETY REMINDER
Safety concerns using these dredges include lifting hazards, pinches, and compressions (several pinch points exist within the jaws and levers). In all cases, handle the dredge by the rope to avoid capturing fingers/hands.

Coring Samplers

Coring samplers are used to sample vertical columns of sediment. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand-push tubes to electronic vibrational core tube drivers.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines at the sediment-water interface are only minimally disturbed. The sample is withdrawn intact, permitting the removal of only those layers of interest.

In shallow, wadeable waters, the use of a core liner or tube manufactured of Teflon or plastic is recommended for the collection of sediment samples. Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water. The general procedure to collecting a sediment sample with a core tube is as follows:

1. Push the tube into the substrate until 4 inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction.

2. Cop the top of the tube to provide suction and reduce the chance of losing the sample.

3. Slowly extract the tube so as not to lose sediment from the bottom of the tube. Cap the bottom of the tube before removing it from the water. This will also help to minimize loss of sample.

4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis prior to homogenization. Homogenize the remainder of the sediment collected.

5. Fill the containers for all analyses other and VOCs.

6. Use a paper towel to clean and dry the outside of each container.

7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

In deeper, non-wadeable water bodies, sediment cores may be collected from a bridge or boat using different coring devices such as Ogeechee Sand Pounders, gravity cores, and vibrating coring devices. All three devices utilize a core barrel with a core liner tube system. The core liners can be removed from the core barrel and replaced with a clean core liner after each sample. Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by turning the core tube to its side and gently pouring the liquid out until fine sediment particles appear in the waste liquid. Post-retrieval processing of samples is the same as above.

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ATTACHMENT A
SURFACE WATER SAMPLE LOG SHEET

Tetra Tech

SURFACE WATER SAMPLE LOG SHEET

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Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA:

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

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

APPENDIX C
GUIDANCE ON SAMPLING DESIGN AND SAMPLE COLLECTION

C.1 Defining the Sampling Program

Many factors are considered in developing a sampling program for surface water and/or sediment, including study objectives, accessibility, site topography, physical characteristics of the water body (e.g., flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on vertical and lateral mixing within the body of water. For sediment, dispersion depends on bottom current or flow characteristics, sediment characteristics (e.g., density, size), and geochemical properties (that affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes but must also understand the role of fluvial-sediment transport, deposition, and chemical sorption.

C.1.1 Sampling Program Objectives

The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., contaminated runoff). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the water body, direct waste disposal (solid or liquid) into the water body, and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompasses the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the locations of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc. shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation include: (1) moving the sampling location far enough downstream to allow for adequate mixing, or (2) collecting integrated samples in a cross section. Also, non-homogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

C.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes, reservoirs, or larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each contaminant would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining stream flow data by direct or indirect methods. Remember these locations are also where you may encounter natural hazards as these are areas where they hunt. Always exercise extreme caution.

C.1.3 Frequency of Sampling

The sampling frequency and objectives of the sampling event will be defined by the project planning documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of a contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples should be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly and during droughts and floods). Samples of bottom material should generally be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

C.2 <u>Surface Water Sample Collection</u>

C.2.1 Streams, Rivers, Outfalls and Drainage Features

Methods for sampling streams, rivers, outfalls, and drainage features (ditches, culverts) at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, and discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of dissolved oxygen (DO), pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project planning documents.

C.2.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, measurement of DO, pH, temperature, etc. is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample if a sample representative of the water column is required. These vertical composites are often collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline that is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer that is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several vertical composites with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality because it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, DO, some cations and anions, and light penetration.

C.2.3 Estuaries

Estuarine areas are, by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Knowledge of the estuary type may be necessary to determine sampling locations. Estuaries are generally categorized into one of the following three types dependent on freshwater inflow and mixing properties:

- Mixed Estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically, this type of estuary is shallow and is found in major freshwater sheet flow areas. Because this type of estuary is well mixed, sampling locations are not critical.

- Salt Wedge Estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally back and forth with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic Estuary - characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small, with the preponderance of the fresh-saline water mixing occurring near or at the shore line.

Sampling in estuarine areas is normally based on the tidal phase, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical DO and temperature profiles.

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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

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

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

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

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

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

5.1 Equipment/Items Needed

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

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

5.2 Well Design

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

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

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

5.2.1 Well Depth, Diameter, and Monitored Interval

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

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

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

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

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

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

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

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

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

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

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

5.2.2 Riser Pipe and Screen Materials

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

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

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

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

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

5.2.3 Annular Materials

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

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

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

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

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

5.2.4 Protective Casing

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

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

5.3 Monitoring Well Installation

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

5.3.1 Monitoring Wells in Unconsolidated Sediments

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

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

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

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

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

~~5.3.2 Confining Layer Monitoring Wells~~

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

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

5.3.3 Bedrock Monitoring Wells

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

~~5.3.4 Drive Points~~

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

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

~~5.3.5 Innovative Monitoring Well Installation Techniques~~

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

5.4 Well Development Methods

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

5.4.1 Overpumping and Backwashing

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

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

5.4.2 Surging with a Surge Plunger

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

~~5.4.3 Compressed Air~~

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

~~5.4.4 High Velocity Jetting~~

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

6.0 RECORDS

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

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

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

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

7.0 REFERENCES

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ATTACHMENT A

RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

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

Preliminary Ranking of Rigid Materials:

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

* Trademark of DuPont

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

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

Preliminary Ranking of Semi-Rigid or Elastomeric Materials:

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

* Trademark of DuPont

Source: Barcelona et al., 1983

ATTACHMENT B

COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

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

* See also Attachment A.

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1.0 PURPOSE

The purpose of this procedure is to describe the methods and equipment necessary to perform soil and rock borings and identify the equipment, sequence of events, and appropriate methods necessary to obtain soil, both surface and subsurface, and rock samples during field sampling activities.

2.0 SCOPE

This guideline addresses most of the accepted and standard drilling techniques, their benefits, and drawbacks. It should be used generally to determine what type of drilling techniques would be most successful depending on site-specific geologic conditions and the type of sampling required.

The sampling methods described within this procedure are applicable to collecting surface and subsurface soil samples, and obtaining rock core samples for lithologic and hydrogeologic evaluation, excavation/foundation design, remedial alternative design and related civil engineering purposes.

3.0 GLOSSARY

Rock Coring - A method in which a continuous solid cylindrical sample of rock or compact rock-like soil is obtained by the use of a double tube core barrel that is equipped with an appropriate diamond-studded drill bit which is advanced with a hydraulic rotary drilling machine.

Wire-Line Coring - As an alternative to conventional coring, this technique is valuable in deep hole drilling, since this method eliminates trips in and out of the hole with the coring equipment. With this technique, the core barrel becomes an integral part of the drill rod string. The drill rod serves as both a coring device and casing.

4.0 RESPONSIBILITIES

Project Manager - In consultation with the project geologist, the Project Manager is responsible for evaluating the drilling requirements for the site and specifying drilling techniques that will be successful given the study objectives and the known or suspected geologic conditions at the site. The Project Manager also determines the disposal methods for products generated by drilling, such as drill cuttings and well development water, as well as any specialized supplies or logistical support required for the drilling operations.

Field Operations Leader (FOL) - The FOL is responsible for the overall supervision and scheduling of drilling activities, and is strongly supported by the project geologist.

Project Geologist - The project geologist is responsible for ensuring that standard and approved drilling procedures are followed. The geologist will generate a detailed boring log for each test hole. This log shall include a description of materials, samples, method of sampling, blow counts, and other pertinent drilling and testing information that may be obtained during drilling (see SOPs SA-6.3 and GH-1.5). Often this position for inspecting the drilling operations may be filled by other geotechnical personnel, such as soils and foundation engineers, civil engineers, etc.

Determination of the exact location for borings is the responsibility of the site geologist. The final location for drilling must be properly documented on the boring log. The general area in which the borings are to be located will be shown on a site map included in the Work Plan and/or Sampling and Analysis Plan.

Drilling Subcontractor - Operates under the supervision of the FOL. Responsible for obtaining all drilling permits and clearances, and supplying all services (including labor), equipment and material required to

perform the drilling, testing, and well installation program, as well as maintenance and quality control of such required equipment except as stated in signed and approved subcontracts.

The driller must report any major technical or analytical problems encountered in the field to the FOL within 24 hours of determination, and must provide advance written notification of any changes in field procedures, describing and justifying such changes. No such changes shall be made unless requested and authorized in writing by the FOL (with the concurrence of the Project Manager). Depending on the subcontract, the Project Manager may need to obtain written authorization from appropriate administrative personnel before approving any changes.

The drilling subcontractor is responsible for following decontamination procedures specified in the project plan documents. Upon completion of the work, the driller is responsible for demobilizing all equipment, cleaning up any materials deposited on site during drilling operations, and properly backfilling any open borings.

5.0 PROCEDURES

5.1 General

The purpose of drilling boreholes is:

- To determine the type, thickness, and certain physical and chemical properties of the soil, water and rock strata which underlie the site.
- To install monitoring wells or piezometers.

All drilling and sampling equipment will be cleaned between samples and borings using appropriate decontamination procedures as outlined in SOP SA-7.1. Unless otherwise specified, it is generally advisable to drill borings at "clean" locations first, and at the most contaminated locations last, to reduce the risk of spreading contamination between locations. All borings must be logged by the site geologist as they proceed (see SOPs SA-6.3 and GH-1.5). Situations where logging would not be required would include installation of multiple well points within a small area, or a "second attempt" boring adjacent to a boring that could not be continued through resistant material. In the latter case, the boring log can be resumed 5 feet above the depth at which the initial boring was abandoned, although the site geologist should still confirm that the stratigraphy at the redrilled location conforms essentially with that encountered at the original location. If significant differences are seen, each hole should be logged separately.

5.2 Drilling Methods

The selected drilling methods described below apply to drilling in subsurface materials, including, but not limited to, sand, gravel, clay, silt, cobbles, boulders, rock and man-made fill. Drilling methods should be selected after studying the site geology and terrain, the waste conditions at the site, and reviewing the purpose of drilling and the overall subsurface investigation program proposed for the site. The full range of different drilling methods applicable to the proposed program should be identified with final selection based on relative cost, availability, time constraints, and how well each method meets the sampling and testing requirements of the individual drilling program.

5.2.1 Continuous-Flight Hollow-Stem Auger Drilling

This method of drilling consists of rotating augers with a hollow stem into the ground. Cuttings are brought to the surface by the rotating action of the auger. This method is relatively quick and inexpensive. Advantages of this type of drilling include:

- Samples can be obtained without pulling the augers out of the hole. However, this is a poor method for obtaining grab samples from thin, discrete formations because of mixing of soils which occurs as the material is brought to the surface. Sampling of such formations requires the use of split-barrel or thin-wall tube samplers advanced through the hollow core of the auger.
- No drilling fluids are required.
- A well can be installed inside the auger stem and backfilled as the augers are withdrawn.

Disadvantages and limitations of this method of drilling include:

- Augering can only be done in unconsolidated materials.

- The inside diameter of hollow stem augers used for well installation should be at least 4 inches greater than the well casing. Use of such large-diameter hollow-stem augers is more expensive than the use of small-diameter augers in boreholes not used for well installation. Furthermore, the density of unconsolidated materials and depths become more of a limiting factor. More friction is produced with the larger diameter auger and subsequently greater torque is needed to advance the boring.

- The maximum effective depth for drilling is 150 feet or less, depending on site conditions and the size of augers used.

- In augering through clean sand formations below the water table, the sand will tend to flow into the hollow stem when the plug is removed for soil sampling or well installation. If the condition of "running" or "flowing" sands is persistent at a site, an alternative method of drilling is recommended, in particular for wells or boreholes deeper than 25 feet.

Hollow-stem auger drilling is the preferred method of drilling. Most alternative methods require the introduction of water or mud downhole (air rotary is the exception) to maintain the open borehole. With these other methods, great care must be taken to ensure that the method does not interfere with the collection of a representative sample (which may be the prime objective of the borehole construction). With this in mind, the preferred order of choice of drilling method after hollow-stem augering (HSA) is:

- Cable tool
- Casing drive (air)
- Air rotary
- Mud rotary
- Rotosonic
- Drive and wash
- Jetting

However, the use of any method will also depend on efficiency and cost-effectiveness. In many cases, mud rotary is the only feasible alternative to hollow-stem augering. Thus, mud rotary drilling is generally acceptable as a first substitute for HSA.

The procedures for sampling soils through holes drilled by hollow-stem auger shall conform with the applicable ASTM Standards: D1587-83 and D1586-84. The guidelines established in SOP SA-1.3 shall also be followed. The hollow-stem auger may be advanced by any power-operated drilling machine having sufficient torque and ram range to rotate and force the auger to the desired depth. The machine must, however, be equipped with the accessory equipment needed to perform required sampling, or rock coring.

The hollow-stem auger may be used without the plug when boring for geotechnical examination or for well installation. However, when drilling below the water table, specially designed plugs which allow

passage of formation water but not solid material shall be used (see Reference 1 of this guideline). This drilling configuration method also prevents blow back and plugging of the auger when the plug is removed for sampling.

Alternately, it may be necessary to keep the hollow stem full of water, at least to the level of the water table, to prevent blowback and plugging of the auger. If water is added to the hole, it must be sampled and analyzed to determine if it is free from contaminants prior to use. In addition, the amount of water introduced, the amount recovered upon attainment of depth, and the amount of water extracted during well development must be carefully logged in order to ensure that a representative sample of the formation water can be obtained. Well development should occur as soon after well completion as practicable (see SOP GH-2.8 for well development procedures). If gravelly or hard material is encountered which prevents advancing the auger to the desired depth, augering should be halted and either driven casing or hydraulic rotary methods should be attempted. If the depth to the bedrock/soil interface and bedrock lithology must be determined, then a 5-foot confirmatory core run should be conducted (see Section 5.2.9).

At the option of the Field Operations Leader (in communication with the Project Manager), when resistant materials prevent the advancement of the auger, a new boring can be attempted. The original boring must be properly backfilled and the new boring started a short distance away at a location determined by the site geologist. If multiple water bearing strata were encountered, the original boring must be grouted. In some formations, it may be prudent to also grout borings which penetrate only the water table aquifer, since loose soil backfill in the boring may still provide a preferred pathway for surface liquids to reach the water table. Backfilling requirements may also be driven by state or local regulations.

5.2.2 Continuous-Flight Solid-Stem Auger Drilling

This drilling method is similar to hollow-stem augering. Practical application of this method is severely restricted compared to use of hollow-stem augers. Split-barrel (split-spoon) sampling cannot be performed without pulling the augers out, which may allow the hole to collapse. The continuous-flight solid-stem auger drilling method is therefore very time consuming and is not cost effective. Also, augers would have to be withdrawn before installing a monitoring well, which again, may allow the hole to collapse. Furthermore, geologic logging by examining the soils brought to the surface is unreliable, and depth to water may be difficult to determine while drilling.

There would be very few situations where use of a solid-stem auger would be preferable to other drilling methods. The only practical applications of this method would be to drill boreholes for well installation where no lithologic information is desired and the soils are such that the borehole can be expected to remain open after the augers are withdrawn. Alternatively, this technique can be used to find depth to bedrock in an area when no other information is required from drilling.

5.2.3 Rotary Drilling

Direct rotary drilling includes air-rotary and fluid-rotary drilling. For air or fluid-rotary drilling, the rotary drill may be advanced to the desired depth by any power-operated drilling machine having sufficient torque and ram range to rotate and force the bit to the desired depth. The drilling machine must, however, be equipped with any accessory equipment needed to perform required sampling, or coring. Prior to sampling, any settled drill cuttings in the borehole must be removed.

Air-rotary drilling is a method of drilling where the drill rig simultaneously turns and exerts a downward pressure on the drilling rods and bit while circulating compressed air down the inside of the drill rods, around the bit, and out the annulus of the borehole. Air circulation serves to both cool the bit and remove the cuttings from the borehole. Advantages of this method include:

- The drilling rate is high (even in rock).
- The cost per foot of drilling is relatively low.
- Air-rotary rigs are common in most areas.
- No drilling fluid is required (except when water is injected to keep down dust).
- The borehole diameter is large, to allow room for proper well installation procedures.

Disadvantages to using this method include:

- Formations must be logged from the cuttings that are blown to the surface and thus the depths of materials logged are approximate.
- Air blown into the formation during drilling may "bind" the formation and impede well development and natural groundwater flow.
- In-situ samples cannot be taken, unless the hole is cased.
- Casing must generally be used in unconsolidated materials.
- Air-rotary drill rigs are large and heavy.
- Large amounts of Investigation Derived Waste (IDW) may be generated which may require containerization, sampling, and off-site disposal.

A variation of the typical air-rotary drill bit is a down hole hammer which hammers the drill bit down as it drills. This makes drilling in hard rock faster. Air-rotary drills can also be adapted to use for rock coring although they are generally slower than other types of core drills. A major application of the air-rotary drilling method would be to drill holes in rock for well installation.

Fluid-Rotary drilling operates in a similar manner to air-rotary drilling except that a drilling fluid ("mud") or clean water is used in place of air to cool the drill bit and remove cuttings. There are a variety of fluids that can be used with this drilling method, including bentonite slurry and synthetic slurries. If a drilling fluid other than water/cuttings is used, it must be a natural clay (i.e., bentonite) and a "background" sample of the fluid should be taken for analysis of possible organic or inorganic contaminants.

Advantages to the fluid-rotary drilling method include:

- The ability to drill in many types of formations.
- Relatively quick and inexpensive.
- Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be obtained without removing drill rods if the appropriate size drill rods and bits (i.e., fish-tail or drag bit) are used.
- In some borings temporary casing may not be needed as the drilling fluids may keep the borehole open.
- Drill rigs are readily available in most areas.

Disadvantages to this method include:

- Formation logging is not as accurate as with hollow-stem auger method if split-barrel (split-spoon) samples are not taken (i.e., the depths of materials logged from cuttings delivered to the surface are approximate).

- Drilling fluids reduce permeability of the formation adjacent to the boring to some degree, and require more extensive well development than "dry" techniques (augering, air-rotary).
- No information on depth to water is obtainable while drilling.
- Fluids are needed for drilling, and there is some question about the effects of the drilling fluids on subsequent water samples obtained. For this reason as well, extensive well development may be required.
- In very porous materials (i.e., rubble fill, boulders, coarse gravel) drilling fluids may be continuously lost into the formation. This requires either constant replenishment of the drilling fluid, or the use of casing through this formation.
- Drill rigs are large and heavy, and must be supported with supplied water.
- Groundwater samples can be potentially diluted with drilling fluid.

The procedures for performing direct rotary soil investigations and sampling shall conform with the applicable ASTM standards: D2113-83, D1587-83, and D1586-84.

Soil samples shall be taken as specified by project plan documents, or more frequently, if requested by the project geologist. Any required sampling shall be performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool.

When field conditions prevent the advancement of the hole to the desired depth, a new boring may be drilled at the request of the Field Operations Leader. The original boring shall be backfilled using methods and materials appropriate for the given site and a new boring started a short distance away at a location determined by the project geologist.

~~5.2.4 Rotosonic Drilling~~

~~The Rotosonic drilling method employs a high frequency vibrational and low speed rotational motion coupled with down pressure to advance the cutting edge of a drill string. This produces a uniform borehole while providing a continuous, undisturbed core sample of both unconsolidated and most bedrock formations. Rotosonic drilling advances a 4-inch diameter to 12-inch diameter core barrel for sampling and can advance up to a 12-inch diameter outer casing for the construction of standard and telescoped monitoring wells. During drilling, the core barrel is advanced ahead of the outer barrel in increments as determined by the site geologist and depending upon type of material, degree of subsurface contamination and sampling objectives.~~

~~The outer casing can be advanced at the same time as the inner drill string and core barrel, or advanced down over the inner drill rods and core barrel, or after the core barrel has moved ahead to collect the undisturbed sample and has been pulled out of the borehole. The outer casing can be advanced dry in most cases, or can be advanced with water or air depending upon the formations being drilled, the depth and diameter of the hole, or requirements of the project.~~

~~Advantages of this method include:~~

- ~~Sampling and well installation are faster as compared to other drilling methods.~~
- ~~Continuous sampling, with larger sample volume as compared to split-spoon sampling.~~

- ~~The ability to drill through difficult formations such as cobbles or boulders, hard till and bedrock.~~
- ~~Reduction of IDW by an average of 70 to 80 percent.~~
- ~~Well installations are quick and controlled by elimination of potential bridging of annular materials during well installation, due to the ability to vibrate the outer casing during removal.~~

~~Disadvantages include:~~

- ~~The cost for Rotosonic drilling as compared to other methods are generally higher. However, the net result can be a significant savings considering reduced IDW and shortened project duration.~~
- ~~Rotosonic drill rigs are large and need ample room to drill, however, Rotosonic units can be placed on the ground or placed on an ATV.~~
- ~~There are a limited number of Rotosonic drilling contractors at the present time.~~

~~5.2.5 Reverse Circulation Rotary Drilling~~

~~The common reverse-circulation rig is a water or mud-rotary rig with a large-diameter drill pipe which circulates the drilling water down the annulus and up the inside of the drill pipe (reverse flow direction from direct mud-rotary). This type of rig is used for the construction of large-capacity production water wells and is not suited for small, water quality sampling wells because of the use of drilling muds and the large-diameter hole which is created. A few special reverse-circulation rotary rigs are made with double-wall drill pipe. The drilling water or air is circulated down the annulus between the drill pipes and up inside the inner pipe.~~

~~Advantages of the latter method include:~~

- ~~The formation water is not contaminated by the drilling water.~~
- ~~Formation samples can be obtained, from known depths.~~
- ~~When drilling with air, immediate information is available regarding the water-bearing properties of formations penetrated.~~
- ~~Collapsing of the hole in unconsolidated formations is not as great a problem as when drilling with the normal air-rotary rig.~~

~~Disadvantages include:~~

- ~~Double-wall, reverse-circulation drill rigs are rare and expensive to operate.~~
- ~~Placing cement grout around the outside of the well casing above a well screen often is difficult, especially when the screen and casing are placed down through the inner drill pipe before the drill pipe is pulled out.~~

~~5.2.6 Drill-through Casing Driver~~

~~The driven-casing method consists of alternately driving casing (fitted with a sharp, hardened casing shoe) into the ground using a hammer lifted and dropped by the drill rig (or an air-hammer) and cleaning out the casing using a rotary chopping bit and air or water to flush out the materials. The casing is driven down in stages (usually 5 feet per stage); a continuous record is kept of the blows per foot in driving the~~

~~casing (see SOP GH-1.5). The casing is normally advanced by a 300-pound hammer falling freely through a height of 30 inches. Simultaneous washing and driving of the casing is not recommended. If this procedure is used, the elevations within which wash water is used and in which the casing is driven must be clearly recorded.~~

~~The driven casing method is used in unconsolidated formations only. When the boring is to be used for later well installation, the driven casing used should be at least 4 inches larger in diameter than the well casing to be installed. Advantages to this method of drilling include:~~

- ~~Split-barrel (split-spoon) sampling can be conducted while drilling.~~
- ~~Well installation is easily accomplished.~~
- ~~Drill rigs used are relatively small and mobile.~~
- ~~The use of casing minimizes flow into the hole from upper water-bearing layers; therefore, multiple aquifers can be penetrated and sampled for rough field determinations of some water quality parameters.~~

~~Some of the disadvantages include:~~

- ~~This method can only be used in unconsolidated formations.~~
- ~~The method is slower than other methods (average drilling progress is 30 to 50 feet per day).~~
- ~~Maximum depth of the borehole varies with the size of the drill rig and casing diameter used, and the nature of the formations drilled.~~
- ~~The cost per hour or per foot of drilling may be substantially higher than other drilling methods.~~
- ~~It is difficult and time consuming to pull back the casing if it has been driven very deep (deeper than 50 feet in many formations).~~

~~5.2.7 Cable Tool Drilling~~

~~A cable tool rig uses a heavy, solid-steel, chisel-type drill bit ("tool") suspended on a steel cable, which when raised and dropped, chisels or pounds a hole through the soils and rock. Drilling progress may be expedited by the use of "slip-jars" which serve as a cable-activated down hole percussion device to hammer the bit ahead.~~

~~When drilling through the unsaturated zone, some water must be added to the hole. The cuttings are suspended in the water and then bailed out periodically. Below the water table, after sufficient ground water enters the borehole to replace the water removed by bailing, no further water needs to be added. When soft caving formations are encountered, it is usually necessary to drive casing as the hole is advanced to prevent collapse of the hole. Often the drilling can be only a few feet below the bottom of the casing. Because the drill bit is lowered through the casing, the hole created by the bit is smaller than the casing. Therefore, the casing (with a sharp, hardened casing shoe on the bottom) must be driven into the hole (see Section 5.2.5 of this guideline).~~

~~Advantages of the cable-tool method include the following:~~

- ~~Information regarding water-bearing zones is readily available during the drilling. Even relative permeabilities and rough water quality data from different zones penetrated can be obtained by skilled operators.~~

- ~~The cable-tool rig can operate satisfactorily in all formations, but is best suited for caving, boulder, cobble or coarse gravel type formations (e.g., glacial till) or formations with large cavities above the water table (such as limestones).~~

- ~~When casing is used, the casing seals formation water out of the hole, preventing down hole contamination and allowing sampling of deeper aquifers for field-measurable water quality parameters.~~

- ~~Split-barrel (split-spoon) or thin-wall (Shelby) tube samples can be collected through the casing.~~

~~Disadvantages include:~~

- ~~Drilling is slow compared with rotary rigs.~~

- ~~The necessity of driving the casing in unconsolidated formations requires that the casing be pulled back if exposure of selected water-bearing zones is desired. This process complicates the well completion process and often increases costs. There is also a chance that the casing may become stuck in the hole.~~

- ~~The relatively large diameters required (minimum of 4-inch casing) plus the cost of steel casing result in higher costs compared to rotary drilling methods where casing is not required (e.g., such use of a hollow-stem auger).~~

- ~~Cable-tool rigs have largely been replaced by rotary rigs. In some parts of the U.S., availability may be difficult.~~

~~5.2.8 Jet Drilling (Washing)~~

~~Jet drilling, which should be used only for piezometer or vadose zone sampler installation, consists of pumping water or drilling mud down through a small diameter (1/2- to 2-inch) standard pipe (steel or PVC). The pipe may be fitted with a chisel bit or a special jetting screen. Formation materials dislodged by the bit and jetting action of the water are brought to the surface through the annulus around the pipe. As the pipe is jetted deeper, additional lengths of pipe may be added at the surface.~~

~~Jet percussion is a variation of the jetting method, in which the casing is driven with a drive weight. Normally, this method is used to place 2-inch-diameter casing in shallow, unconsolidated sand formations, but this method has also been used to install 3- to 4-inch-diameter casings to a depth of 200 feet.~~

~~Jetting is acceptable in very soft formations, usually for shallow sampling, and when introduction of drilling water to the formation is acceptable. Such conditions would occur during rough stratigraphic investigation or installation of piezometers for water level measurement. Advantages of this method include:~~

- ~~Jetting is fast and inexpensive.~~

- ~~Because of the small amount of equipment required, jetting can be accomplished in locations where access by a normal drilling rig would be very difficult. For example, it would be possible to jet down a well point in the center of a lagoon at a fraction of the cost of using a drill rig.~~

- ~~Jetting numerous well points just into a shallow water table is an inexpensive method for determining the water table contours, hence flow direction.~~

~~Disadvantages include the following:~~

- ~~A large amount of foreign water or drilling mud is introduced above and into the formation to be sampled.~~
- ~~Jetting is usually done in very soft formations which are subject to caving. Because of this caving, it is often not possible to place a grout seal above the screen to assure that water in the well is only from the screened interval.~~
- ~~The diameter of the casing is usually limited to 2 inches.~~
- ~~Jetting is only possible in very soft formations that do not contain boulders or coarse gravel, and the depth limitation is shallow (about 30 feet without jet percussion equipment).~~
- ~~Large quantities of water are often needed.~~

5.2.9 Drilling with a Hand Auger

This method is applicable wherever the formation, total depth of sampling, and the site and groundwater conditions are such as to allow hand auger drilling. Hand augering can also be considered at locations where drill rig access is not possible. All hand auger borings will be performed according to ASTM D1452-80.

Samples should be taken continuously unless otherwise specified by the project plan documents. Any required sampling is performed by rotation, pressing, or driving in accordance with the standard or approved method governing use of the particular sampling tool. Typical equipment used for sampling and advancing shallow "hand auger" holes are Iwan samplers (which are rotated) or post hole diggers (which are operated like tongs). These techniques are slow but effective where larger pieces of equipment do not have access, and where very shallow holes are desired (less than 15 feet). Surficial soils must be composed of relatively soft and non-cemented formations to allow penetration by the auger.

5.2.10 Rock Drilling and Coring

When soil borings cannot be continued using augers or rotary methods due to the hardness of the soil or when rock or large boulders are encountered, drilling and sampling can be performed using a diamond bit corer in accordance with ASTM D2113.

Drilling is done by rotating and applying downward pressure to the drill rods and drill bit. The drill bit is a circular, hollow, diamond-studded bit attached to the outer core barrel in a double-tube core barrel. The use of single-tube core barrels is not recommended, as the rotation of the barrel erodes the sample and limits its use for detailed geological evaluation. Water or air is circulated down through the drill rods and annular space between the core barrel tubes to cool the bit and remove the cuttings. The bit cuts a core out of the rock which rises into an inner barrel mounted inside the outer barrel. The inner core barrel and rock core are removed by lowering a wire line with a coupling into the drill rods, latching onto the inner barrel and withdrawing the inner barrel. A less efficient variation of this method utilizes a core barrel that cannot be removed without pulling all of the drill rods. This variation is practical only if less than 50 feet of core is required.

Core borings are made through the casing used for the soil borings. The casing must be driven and sealed into the rock formation to prevent seepage from the overburden into the hole to be cored (see

Section 5.3 of this guideline). A double-tube core barrel with a diamond bit and reaming shell or equivalent should be used to recover rock cores of a size specified in the project plans. The most common core barrel diameters are listed in Attachment A.

Soft or decomposed rock should be sampled with a driven split-barrel whenever possible or cored with a Denison or Pitcher sampler.

When coring rock, including shale and claystone, the speed of the drill and the drilling pressure, amount and pressure of water, and length of run can be varied to give the maximum recovery from the rock being drilled. Should any rock formation be so soft or broken that the pieces continually fall into the hole causing unsatisfactory coring, the hole should be reamed and a flush-joint casing installed to a point below the broken formation. The size of the flush-joint casing must permit securing the core size specified. When soft or broken rock is anticipated, the length of core runs should be reduced to less than 5 feet to avoid core loss and minimize core disturbance.

Advantages of core drilling include:

- Undisturbed rock cores can be recovered for examination and/or testing.
- In formations in which the cored hole will remain open without casing, water from the rock fractures may be recovered from the well without the installation of a well screen and gravel pack.
- Formation logging is extremely accurate.
- Drill rigs are relatively small and mobile.

Disadvantages include:

- Water or air is needed for drilling.
- Coring is slower than rotary drilling (and more expensive).
- Depth to water cannot accurately be determined if water is used for drilling.
- The size of the borehole is limited.

This drilling method is useful if accurate determinations of rock lithology are desired or if open wells are to be installed into bedrock. To install larger diameter wells in coreholes, the hole must be reamed out to the proper size after boring, using air or mud rotary drilling methods.

5.2.11 Drilling & Support Vehicles

In addition to the drilling method required to accomplish the objectives of the field program, the type of vehicle carrying the drill rig and/or support equipment and its suitability for the site terrain, will often be an additional deciding factor in planning the drilling program. The types of vehicles available are extensive, and depend upon the particular drilling subcontractor's fleet. Most large drilling subcontractors will have a wide variety of vehicle and drill types suited for most drilling assignments in their particular region, while smaller drilling subcontractors will usually have a fleet of much more limited diversity. The weight, size, and means of locomotion (tires, tracks, etc.) of the drill rig must be selected to be compatible with the site terrain to assure adequate mobility between borehole locations. Such considerations also apply to necessary support vehicles used to transport water and/or drilling materials to the drill rigs at the borehole locations. When the drill rigs or support vehicles do not have adequate mobility to easily traverse the site, provisions must be made for assisting equipment, such as bulldozers, winches, timber planking, etc., to maintain adequate progress during the drilling program.

Some of the typical vehicles which are usually available for drill rigs and support equipment are:

- Totally portable drilling/sampling equipment, where all necessary components (tripods, samplers, hammers, catheads, etc.) may be hand carried to the borehole site. Drilling/sampling methods used with such equipment include:

  - Hand augers and lightweight motorized augers.
  - Retractable plug samplers--driven by hand (hammer).
  - Motorized cathead - a lightweight aluminum tripod with a small gas-engine cathead mounted on one leg, used to install small-diameter cased borings. This rig is sometimes called a "monkey on a stick."

- Skid-mounted drilling equipment containing a rotary drill or engine-driven cathead (to lift hammers and drill string), a pump, and a dismounted tripod. The skid is pushed, dragged, or winched (using the cathead drum) between boring locations.

- Small truck-mounted drilling equipment using a Jeep, stake body or other light truck (4 to 6 wheels), upon which are mounted the drill and/or a cathead, a pump, and a tripod or small drilling derrick. On some rigs, the drill and/or a cathead are driven by a power take-off from the truck, instead of by a separate engine.

- Track-mounted drilling equipment is similar to truck-mounted rigs, except that the vehicle used has wide bulldozer tracks for traversing soft ground. Sometimes a continuous-track "all terrain vehicle" is also modified for this purpose. Some types of tracked drill rigs are called "bombardier" or "weasel" rigs.

- Heavy truck-mounted drilling equipment is mounted on tandem or dual tandem trucks to transport the drill, derrick, winches, and pumps or compressors. The drill may be provided with a separate engine or may use a power take-off from the truck engine. Large augers, hydraulic rotary and reverse circulation rotary drilling equipment are usually mounted on such heavy duty trucks. For soft-ground sites, the drilling equipment is sometimes mounted on vehicles having low pressure, very wide diameter tires and capable of floating; these vehicles are called "swamp buggy" rigs.

- Marine drilling equipment is mounted on various floating equipment for drilling borings in lakes, estuaries and other bodies of water. The floating equipment varies, and is often manufactured or customized by the drilling subcontractor to suit specific drilling requirements. Typically, the range of flotation vehicles include:

  - Barrel-float rigs - a drill rig mounted on a timber platform buoyed by empty 55-gallon drums or similar flotation units.

  - Barge-mounted drill rigs.

  - Jack-up platforms - drilling equipment mounted on a floating platform having retractable legs to support the unit on the sea or lake bed when the platform is jacked up out of the water.

  - Drill ships - for deep ocean drilling.

In addition to the mobility for the drilling equipment, similar consideration must be given for equipment to support the drilling operations. Such vehicles or floating equipment are needed to transport drill water, drilling supplies and equipment, samples, drilling personnel, etc. to and/or from various boring locations.

5.2.12 Equipment Sizes

In planning subsurface exploration programs, care must be taken in specifying the various drilling components, so that they will fit properly in the boring or well.

For drilling open boreholes using rotary drilling equipment, tri-cone drill bits are employed with air, water or drilling mud to remove cuttings and cool the bit. Tri-cone bits are slightly smaller than the holes they drill (i.e., 5-7/8-inch or 7-7/8-inch bits will nominally drill 6-inch and 8-inch holes, respectively).

For obtaining split-barrel samples of a formation, samplers are commonly manufactured in sizes ranging from 2 inches to 3-1/2 inches in outside diameter. However, the most commonly used size is the 2-inch O.D., 1-3/8-inch I.D. split-barrel sampler. When this sampler is used and driven by a 140-pound (∀ 2-pound) hammer dropping 30 inches (∀ 1 inch), the procedure is called a Standard Penetration Test, and the blows per foot required to advance the sampler into the formation can be correlated to the formation's density or strength.

In planning the drilling of boreholes using hollow-stem augers or casing, in which thin-wall tube samples or diamond core drilling will be performed, refer to the various sizes and clearances provided in Attachment A of this guideline. Sizes selected must be stated in the project plan documents.

5.2.13 Estimated Drilling Progress

To estimate the anticipated rates of drilling progress for a site, the following must be considered:

- The speed of the drilling method employed.
- Applicable site conditions (e.g., terrain, mobility between borings, difficult drilling conditions in bouldery soils, rubble fill or broken rock, etc.).
- Project-imposed restrictions (e.g., drilling while wearing personal protective equipment, decontamination of drilling equipment, etc.).

Based on recent experience in drilling average soil conditions (no boulders) and taking samples at 5-foot intervals, for moderate depth (30 feet to 50 feet) boreholes (not including installation or development of wells), the following daily rates of total drilling progress may be anticipated for the following drilling methods:

Drilling Method	Average Daily Progress (linear feet)
Hollow-stem augers	75'
Solid-stem augers	50'
Mud-Rotary Drilling	100' (cuttings samples)
Rotosonic Drilling	100'-160' (continuous core)
Reverse-Circulation Rotary	100' (cuttings samples)
Skid-Rig with driven casing	30'
Rotary with driven casing	50'
Cable Tool	30'
Hand Auger	Varies
Continuous Rock Coring	50'

5.3 Prevention of Cross-Contamination

A telescoping or multiple casing technique minimizes the potential for the migration of contaminated groundwater to lower strata below a confining layer. The telescoping technique consists of drilling to a confining layer utilizing a spun casing method with a diamond cutting or augering shoe (a method similar to the rock coring method described in Section 5.2.10, except that larger casing is used) or by using a driven-casing method (see Section 5.2.6 of this guideline) and installing a specified diameter steel well casing. The operation consists of three separate steps. Initially, a drilling casing (usually of 8-inch diameter) is installed followed by installation of the well casing (6-inch-diameter is common for 2-inch wells). This well casing is driven into the confining layer to ensure a tight seal at the bottom of the hole. The well casing is sealed at the bottom with a bentonite-cement slurry. The remaining depth of the boring is drilled utilizing a narrower diameter spun or driven casing technique within the outer well casing. A smaller diameter well casing with an appropriate length of slotted screen on the lower end, is installed to the surface.

Clean sand is placed in the annulus around and to a point of about 2 feet above the screen prior to withdrawal of the drilling casing. The annular space above the screen and to a point 2 feet above the bottom of the outer well casing is sealed with a tremied cement-bentonite slurry which is pressure-grouted or displacement-grouted into the hole. The remaining casing annulus is backfilled with clean material and grouted at the surface, or it is grouted all the way to the surface.

5.4 Cleanout of Casing Prior to Sampling

The boring hole must be completely cleaned of disturbed soil, segregated coarse material and clay adhering to the inside walls of the casing. The cleaning must extend to the bottom edge of the casing and, if possible, a short distance further (1 or 2 inches) to bypass disturbed soil resulting from the advancement of the casing. Loss of wash water during cleaning should be recorded.

For disturbed samples both above and below the water table and where introduction of relatively large volumes of wash water is permissible, the cleaning operation is usually performed by washing the material out of the casing with water; however, the cleaning should never be accomplished with a strong, downward-directed jet which will disturb the underlying soil. When clean out has reached the bottom of the casing or slightly below (as specified above), the string of tools should be lifted one foot off the bottom with the water still flowing, until the wash water coming out of the casing is clear of granular soil particles. In formations where the cuttings contain gravel and other larger particles, it is often useful to repeatedly raise and lower the drill rods and wash bit while washing out the hole, to surge these large particles upward out of the hole. As a time saver, the drilling contractor may be permitted to use a split-barrel (split-spoon) sampler with the ball check valve removed as the clean-out tool, provided the material below the spoon is not disturbed and the shoe of the spoon is not damaged. However, because the ball check valve has been removed, in some formations it may be necessary to install a flap valve or spring sample retainer in the split-spoon bit, to prevent the sample from falling out as the sampler is withdrawn from the hole. The use of jet-type chopping bits is discouraged except where large boulders and cobbles or hard-cemented soils are encountered. If water markedly softens the soils above the water table, clean out should be performed dry with an auger.

For undisturbed samples below the water table, or where wash water must be minimized, clean out is usually accomplished with an appropriate diameter clean out auger. This auger has cutting blades at the bottom to carry loose material up into the auger, and up-turned water jets just above the cutting blades to carry the removed soil to the surface. In this manner, there is a minimum of disturbance at the top of the material to be sampled. If any gravel material washes down into the casing and cannot be removed by the clean out auger, a split-barrel sample can be taken to remove it; bailers and sandpumps should not

be used. For undisturbed samples above the groundwater table, all operations must be performed in a dry manner.

If all of the cuttings created by drilling through the overlying formations are not cleaned from the borehole prior to sampling, some of the problems which may be encountered during sampling include:

- When sampling is attempted through the cuttings remaining in the borehole, all or part of the sampler may become filled with the cuttings. This limits the amount of sample from the underlying formation which can enter and be retained in the sampler, and also raises questions as to the validity of the sample.

- If the cuttings remaining in the borehole contain coarse gravel and/or other large particles, these may block the bit of the sampler and prevent any materials from the underlying formation from entering the sampler when the sampler is advanced.

- In cased borings, should sampling be attempted through cuttings which remain in the lower portion of the casing, these cuttings could cause the sampler to become bound into the casing, such that it becomes very difficult to either advance or retract the sampler.

- When sampler blow counts are used to estimate the density or strength of the formation being sampled, the presence of cuttings in the borehole will usually give erroneously high sample blow counts.

To confirm that all cuttings have been removed from the borehole prior to attempting sampling, it is important that the site geologist measure the "stickup" of the drill string. This is accomplished by measuring the assembled length of all drill rods and bits or samplers (the drill string) as they are lowered to the bottom of the hole, below some convenient reference point of the drill string, then measuring the height of this reference point above the ground surface. The difference of these measurements is the depth of the drill string (lower end of the bit or sampler) below the ground surface, which must then be compared with the depth of sampling required (installed depth of casing or depth of borehole drilled). If the length of drill string below grade is more than the drilled or casing depth, the borehole has been cleaned too deeply, and this deeper depth of sampling must be recorded on the log. If the length of drill string below grade is less than the drilled or casing depth, the difference represents the thickness of cuttings which remain in the borehole. In most cases, an inch or two of cuttings may be left in the borehole with little or no problem. However, if more than a few inches of cuttings are encountered, the borehole must be recleaned prior to attempting sampling.

5.5 Materials of Construction

The effects of monitoring well construction materials on specific chemical analytical parameters are described and/or referenced in SOP GH-2.8. However, there are several materials used during drilling, particularly drilling fluids and lubricants, which must be used with care to avoid compromising the representativeness of soil and ground water samples.

The use of synthetic or organic polymer slurries is not permitted at any location where soil samples for chemical analysis are to be collected. These slurry materials could be used for installation of long-term monitoring wells, but the early time data in time series collection of ground water data may then be suspect. If synthetic or organic polymer muds are proposed for use at a given site, a complete written justification including methods and procedures for their use must be provided by the site geologist and approved by the Project Manager. The specific slurry composition and the concentration of suspected contaminants for each site must be known.

For many drilling operations, potable water is an adequate lubricant for drill stem and drilling tool connections. However, there are instances, such as drilling in tight clayey formations or in loose gravels, when threaded couplings must be lubricated to avoid binding. In these instances, to be determined in the field by the judgment of the site geologist and noted in the site logbook, and only after approval by the Project Manager, a vegetable oil or silicone-based lubricant should be used. Petroleum based greases, etc. will not be permitted. Samples of lubricants used must be provided and analyzed for chemical parameters appropriate to the given site.

5.6 Subsurface Soil Samples

Subsurface soil samples are used to characterize subsurface stratigraphy. This characterization can indicate the potential for migration of chemical contaminants in the subsurface. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of the soil samples. Where the remedial activities may include in-situ treatment or excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Engineering and physical properties of soil may also be of interest should site construction activities be planned. Soil types, grain size distribution, shear strength, compressibility, permeability, plasticity, unit weight, and moisture content are some of the physical characteristics that may be determined for soil samples.

Penetration tests are also described in this procedure. The tests can be used to estimate various physical and engineering parameters such as relative density, unconfined compressive strength, and consolidation characteristics of soils.

Surface protocols for various soil sampling techniques are discussed in SOP SA-1.3. Continuous-core soil sampling and rock coring are discussed below. The procedures described here are representative of a larger number of possible drilling and sampling techniques. The choice of techniques is based on a large number of variables such as cost, local geology, etc. The final choice of methods must be made with the assistance of drilling subcontractors familiar with the local geologic conditions. Alternative techniques must be based upon the underlying principles of quality assurance implicit in the following procedures.

The CME continuous sample tube system provides a method of sampling soil continuously during hollow-stem augering. The 5-foot sample barrel fits within the lead auger of a hollow-auger column. The sampling system can be used with a wide range of I.D. hollow-stem augers (from 3-1/4-inch to 8-1/4-inch I.D.). This method has been used to sample many different materials such as glacial drift, hard clays and shales, mine tailings, etc. This method is particularly used when SPT samples are not required and a large volume of material is needed. Also, this method is useful when a visual description of the subsurface lithology is required. Rotosonic drilling methods also provide a continuous soil sample.

5.7 Rock Sampling (Coring) (ASTM D2113-83)

Rock coring enables a detailed assessment of borehole conditions to be made, showing precisely all lithologic changes and characteristics. Because coring is an expensive drilling method, it is commonly used for shallow studies of 500 feet or less, or for specific intervals in the drill hole that require detailed logging and/or analyzing. Rock coring can, however, proceed for thousands of feet continuously, depending on the size of the drill rig, and yields better quality data than air-rotary drilling, although at a substantially reduced drilling rate. Rate of drilling varies widely, depending on the characteristics of lithologies encountered, drilling methods, depth of drilling, and condition of drilling equipment. Average output in a 10-hour day ranges from 40 to over 200 feet. Down hole geophysical logging or television camera monitoring is sometimes used to complement the data generated by coring.

Borehole diameter can be drilled to various sizes, depending on the information needed. Standard sizes of core barrels (showing core diameter) and casing are shown in Figure 1.

Core drilling is used when formations are too hard to be sampled by soil sampling methods and a continuous solid sample is desired. Usually, soil samples are used for overburden, and coring begins in sound bedrock. Casing is set into bedrock before coring begins to prevent loose material from entering the borehole, to prevent loss of drilling fluid, and to prevent cross-contamination of aquifers.

Drilling through bedrock is initiated by using a diamond-tipped core bit threaded to a drill rod (outer core barrel) with a rate of drilling determined by the downward pressure, rotation speed of drill rods, drilling fluid pressure in the borehole, and the characteristics of the rock (mineralogy, cementation, weathering).

FIGURE 1

STANDARD SIZES OF CORE BARRELS AND CASING

Coring Bit Size	Nominal*		Set Size*	
	O.D.	I.D.	O.D.	I.D.
RWT	1 5/32	3/4	1.160	0.735
EWT	1 1/2	29/32	1.470	0.905
EX, EXL, EWG, EWM	1 1/2	13/16	1.470	0.845
AWT	1 7/8	1 9/32	1.875	1.281
AX, AXL, AWG, AWM	1 7/8	1 3/16	1.875	1.185
BWT	2 3/8	1 3/4	2.345	1.750
BX, BXL, BWG, BWM	2 3/8	1 5/8	2.345	1.655
NWT	3	2 5/16	2.965	2.313
NX, NXL, NWG, NWM	3	2 1/8	2.965	2.155
HWT	3 29/32	3 3/16	3.889	3.187
HWG	3 29/32	3	3.889	3.000
2 3/4 x 3 7/8	3 7/8	2 3/4	3.840	2.690
4 x 5 1/2	5 1/2	4	5.435	3.970
6 x 7 3/4	7 3/4	6	7.655	5.970
AX Wire line ___|___/	1 7/8	1	1.875	1.000
BX Wire line ___|___/	2 3/8	1 7/16	2.345	1.437
NX Wire line ___|___/	3	1 15/16	2.965	1.937

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.
___|___/ Wire line dimensions and designations may vary according to manufacturer.

FIGURE 1
STANDARD SIZES OF CORE BARRELS AND CASING
PAGE TWO

Size Designations		Casing O.D., Inches	Casing Coupling		Casing bit O.D., Inches	Core barrel bit O.D., Inches*	Drill rod O.D., Inches	Approximate Core Diameter	
Casing; Casing coupling; Casing bits; Core barrel bits	Rod; rod couplings		O.D., Inches	I.D., Inches				Normal, Inches	Thinwall, Inches
RX	RW	1.437	1.437	1.188	1.485	1.160	1.094	---	0.735
EX	E	1.812	1.812	1.500	1.875	1.470	1.313	0.845	0.905
AX	A	2.250	2.250	1.906	2.345	1.875	1.625	1.185	1.281
BX	B	2.875	2.875	2.375	2.965	2.345	1.906	1.655	1.750
NX	N	3.500	3.500	3.000	3.615	2.965	2.375	2.155	2.313
HX	HW	4.500	4.500	3.938	4.625	3.890	3.500	3.000	3.187
RW	RW	1.437	Flush Joint	No Coupling	1.485	1.160	1.094	---	0.735
EW	EW	1.812			1.875	1.470	1.375	0.845	0.905
AW	AW	2.250			2.345	1.875	1.750	1.185	1.281
BW	BW	2.875			2.965	2.345	2.125	1.655	1.750
NW	NW	3.500			3.615	2.965	2.625	2.155	2.313
HW	HW	4.500			4.625	3.890	3.500	3.000	3.187
PW	---	5.500			5.650	---	---	---	---
SW	---	6.625			6.790	---	---	---	---
UW	---	7.625			7.800	---	---	---	---
ZW	---	8.625			8.810	---	---	---	---
---	AX __|__\	---	---	---	---	1.875	1.750	1.000	---
---	BX __|__\	---	---	---	---	2.345	2.250	1.437	---
---	NX __|__\	---	---	---	---	2.965	2.813	1.937	---

* All dimensions are in inches; to convert to millimeters, multiply by 25.4.
___|___/ Wire line dimensions and designations may vary according to manufacturer.

NOMINAL DIMENSIONS FOR DRILL CASINGS AND ACCESSORIES. (DIAMOND CORE DRILL MANUFACTURERS ASSOCIATION). 288-D-2889

5.7.1 Diamond Core Drilling

A penetration of typically less than 6 inches per 50 blows using a 140-lb. hammer dropping 30 inches with a 2-inch split-barrel sampler shall be considered an indication that soil sampling methods may not be applicable and that coring may be necessary to obtain samples.

When formations are encountered that are too hard to be sampled by soil sampling methods, the following diamond core drilling procedure may be used:

- Firmly seat a casing into the bedrock or the hard material to prevent loose materials from entering the hole and to prevent the loss of drilling fluid return. Level the surface of the rock or hard material when necessary by the use of a fishtail or other bits. If the drill hole can be retained open without the casing and if cross-contamination of aquifers in the unconsolidated materials is unlikely, leveling may be omitted.

- Begin the core drilling using a double-tube swivel-core barrel of the desired size. After drilling no more than 10 feet (3 m), remove the core barrel from the hole and take out the core. If the core blocks the flow of the drilling fluid during drilling, remove the core barrel immediately. In soft materials, a large starting size may be specified for the coring tools; where local experience indicates satisfactory core recovery or where hard, sound materials are anticipated, a smaller size or the single-tube type may be specified and longer runs may be drilled. NX/NW size coring equipment is the most commonly used size.

- When soft materials are encountered that produce less than 50 percent recovery, stop the core drilling. If soil samples are desired, secure such samples in accordance with the procedures described in ASTM Method D 1586 (Split-barrel Sampling) or in Method D 1587 (Thin-Walled Tube Sampling); sample soils per SOP SA-1.3. Resume diamond core drilling when refusal materials are again encountered.

- Since rock structures and the occurrence of seams, fissures, cavities, and broken areas are among the most important items to be detected and described, take special care to obtain and record these features. If such broken zones or cavities prevent further advance of the boring, one of the following three steps shall be taken: (1) cement the hole; (2) ream and case; or (3) case and advance with the next smaller size core barrel, as conditions warrant.

- In soft, seamy, or otherwise unsound rock, where core recovery may be difficult, M-design core barrels may be used. In hard, sound rock where a high percentage of core recovery is anticipated, the single-tube core barrel may be employed.

5.7.2 Rock Sample Preparation and Documentation

Once the rock coring has been completed and the core recovered, the rock core shall be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery as well as the rock quality designation (RQD). Each core shall be described, classified, and logged using a uniform system as presented in SOP GH-1.5. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of clay formations) or oxidation of the core, the core shall be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number, and the footage represented in each sleeve shall be included, as well as designating the top and bottom of the core run.

After sampling, rock cores shall be placed in the sequence of recovery in well-constructed wooden boxes provided by the drilling contractor. Rock cores from two different borings shall not be placed in the same

core box unless accepted by the Project Geologist. The core boxes shall be constructed to accommodate at least 20 linear feet of core in rows of approximately 5 feet each and shall be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened down. Wood partitions shall be placed at the end of each core run and between rows.

The depth from the surface of the boring to the top and bottom of the drill run and run number shall be marked on the wooden partitions with indelible ink. A wooden partition (wooden block) shall be placed at the end of each run with the depth of the bottom of the run written on the block. These blocks will serve to separate successive core runs and indicate depth intervals for each run. The order of placing cores shall be the same in all core boxes. Rock core shall be placed in the box so that, when the box is open, with the inside of the lid facing the observer, the top of the cored interval contained within the box is in the upper left corner of the box, and the bottom of the cored interval is in the lower right corner of the box. The top and bottom of each core obtained and its true depth shall be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, an empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data on the box's contents. At a minimum, the following information shall be included:

- Project name.
- Project number.
- Boring number.
- Run numbers.
- Footage (depths).
- Recovery.
- RQD (%).
- Box number and total number of boxes for that boring (Example: Box 5 of 7).

For easy retrieval when core boxes are stacked, the sides and ends of the box shall also be labeled and include project number, boring number, top and bottom depths of core and box number.

Prior to final closing of the core box, a photograph of the recovered core and the labeling on the inside cover shall be taken. If moisture content is not critical, the core shall be wetted and wiped clean for the photograph. (This will help to show true colors and bedding features in the cores).

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ATTACHMENT A

DRILLING EQUIPMENT SIZES

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Hollow-stem augers (Ref. 7)	6 1/4	5	2 1/4	
	6 3/4	5 3/4	2 3/4	---
	7 1/4	6 1/4	3 1/4	---
	13 1/4	12	6	---
Thin Wall Tube Samplers (Ref. 7)	---	2	1 7/8	---
	---	2 1/2	2 3/8	---
	---	3	2 7/8	---
	---	3 1/2	3 3/8	---
	---	4 1/2	4 3/8	---
	---	5	4 3/4	---
Drill Rods (Ref. 7)	RW	1 3/32	23/32	13/32
	EW	1 3/8	15/16	7/16
	AW	1 3/4	1 1/4	5/8
	BW	2 1/8	1 3/4	3/4
	NW	2 5/8	2 1/4	1 3/8
	HW	3 1/2	3 1/16	2 3/8
	E	1 5/16	7/8	7/16
	A	1 5/8	1 1/8	9/16
	B	1 7/8	1 1/4	5/8
	N	2 3/8	2	1
				Wall Thickness (Inches)
Driven External Coupled Extra Strong Steel* Casing (Ref. 8)	2 1/2	2.875	2.323	0.276
	3	3.5	2.9	0.300
	3 1/2	4.0	3.364	0.318
	4	4.5	3.826	0.337
	5	5.63	4.813	0.375
	6	6.625	5.761	0.432
	8	8.625	7.625	0.500
	10	10.750	9.750	0.500
	12	12.750	11.750	0.500

* Add twice the casing wall thickness to casing O.D. to obtain the approximate O.D. of the external pipe couplings.

ATTACHMENT A
DRILLING EQUIPMENT SIZES

PAGE TWO

Drilling Component	Designation or Hole Size (Inches)	O.D. (Inches)	I.D. (Inches)	Coupling I.D. (Inches)
Flush Coupled Casing (Ref. 7)	RX	1 7/16	1 3/16	1 3/16
	EX	1 13/16	1 5/8	1 1/2
	AX	2 1/4	2	1 29/32
	BX	2 7/8	2 9/16	2 3/8
	NX	3 1/2	3 3/16	3
	HX	4 1/2	4 1/8	3 15/16
Flush Joint Casing (Ref. 7)	RW	1 7/16	1 3/16	
	EW	1 13/16	1 1/2	
	AW	2 1/4	1 29/32	
	BW	2 7/8	2 3/8	
	NW	3 1/2	3	
	HW	4 1/2	4	
	PW	5 1/2	5	
	SW	6 5/8	6	
	UW	7 5/8	7	
	ZW	8 5/8	8	
Diamond Core Barrels (Ref. 7)	EWM	1 1/2	7/8**	
	AWM	1 7/8	1 1/8**	
	BWM	2 3/8	1 5/8**	
	NWM	3	2 1/8	
	HWG	3 7/8	3	
	2 3/4 x 3 7/8	3 7/8	2 11/16	
	4 x 5 1/2	5 1/2	3 15/16	
	6 x 7 3/4	7 3/4	5 15/16	
	AQ (wireline)	1 57/64	1 1/16**	
	BQ (wireline)	2 23/64	1 7/16**	
	NQ (wireline)	2 63/64	1 7/8	
	HQ (wireline)	3 25/32	2 1/2	

** Because of the fragile nature of the core and the difficulty to identify rock details, use of small-diameter core (1 3/8") is not recommended.

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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

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

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

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

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

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

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

5.1 Preliminary Evaluation

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

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

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

5.2 Field Inspection

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

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

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

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

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

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

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

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

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

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

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

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

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

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

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

5.3.2 Water Level Measuring Techniques

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

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

5.3.3 Methods

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

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

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

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

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

5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

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

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

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

~~**Popper or Bell Sounder**~~

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

~~**Pressure Transducer**~~

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

~~**Borehole Geophysics**~~

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

5.3.5 Data Recording

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

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

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

5.4 Equipment Decontamination

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

5.5 Health and Safety Considerations

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

6.0 RECORDS

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

ATTACHMENT A
MONITORING WELL INSPECTION SHEET

Monitoring Well Inspection Sheet

Project Name: _____ Date: _____

Location: _____ Time: _____

Tidally Influenced: Y / N Personnel: _____

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

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

Check List:

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

Condition of Well:

Protective Case:
Riser:
Well Pad:
Other:

Presence/Evidence of:

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

Comments:

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

ATTACHMENT B
GROUNDWATER LEVEL MESUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

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

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

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

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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 GLOSSARY

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

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

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

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

n.o.s. - Not otherwise specified.

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

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

Common Preservatives:

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

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

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

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

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

4.0 RESPONSIBILITIES

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

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

5.0 PROCEDURES

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

5.1 Sample Containers

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

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological

changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

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U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration			Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER						
Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[9]
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO_3 to pH ≤2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days
SOIL						
Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR						
Volatile Organics	Low/Medium		Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH 2; H_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] HCl to pH 2 [9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5 [10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Benzidines[11], [12]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11], [14]	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PCBs[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs)[11],[14]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
(5) Should only be used in the presence of residual chlorine.
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
(7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

STANDARD OPERATING PROCEDURE
MUNITIONS RESPONSE PROGRAM (MRP) SOP 11
GPS DATA COLLECTION AND TRANSFER

1.0 OVERVIEW

The primary purpose of this Standard Operating Procedure (SOP) is to provide the Field Technicians with basic instructions for operating a handheld Global Positioning System (GPS) unit allowing them to set GPS parameters in the receiver, record GPS positions on the field device, and transfer the data for integration into existing Geographic Information System (GIS) figures.

This SOP is specific to GIS quality data collection for Trimble-specific hardware and software.

If possible, the Trimble GeoXT or XH Operators Manual should be downloaded onto the operator's personal computer for reference before or while in the field. The manual can be downloaded at the following website:
http://trl.trimble.com/docushare/dsweb/Get/Document-311749/TerraSyncReferenceManual.pdf

Unless the operator is proficient in the setup and operation of the GPS unit, the Project Manager (or designee) should have the GPS unit shipped to the project-specific contact listed below in the Pittsburgh, Pennsylvania office at least five working days prior to field mobilization so project-specific data files (i.e. shape files), background images, data dictionaries, and correct coordinate systems can be uploaded into the unit.

Tetra Tech NUS
Attn: Ralph Basinski
661 Anderson Drive, Bldg #7
Pittsburgh, PA 15220

The SOP also describes how field collected data is to be transferred through the use of the MRP Website. (http://www.ttnus.com/MRPRepository/). This website serves as a centralized portal to facilitate data exchange for field personnel, GIS staff, and project managers. The website contains a "Reference" page that will contain the latest version of this SOP and other valuable documentation.

For technical questions regarding operation of the GPS units, data collection, general questions about this SOP, and use of the MRP website, please contact Kevin Moore (kevin.moore@tetratech.com).

2.0 REQUIRED EQUIPMENT

The following hardware and software should be utilized for locating and establishing GPS points in the field:

2.1 GPS Hardware & Equipment

- Hand-held GPS Unit capable of sub-meter accuracy. This includes the docking cradle, a/c adapter, stylus, and USB cable for data transfer. Two models, the GeoXH and GeoXT, are acceptable for use. The XH yields higher accuracy (in both real-time and post-processed) and should always be requested when highly precise data is required.

- An external antenna will yield better satellite reception, especially in heavy tree canopy. Associated accessories include a range pole and hardware clamp, for mounting the GPS unit to the pole.

- Indelible marker.

- Non-metallic pin flags for temporary marking of positions.

2.2 GPS Software

The following software is required to transfer data from the handheld GPS unit to a personal computer:

- Trimble TerraSync version 2.6 or later (pre-loaded onto GPS unit from vendor)

- Microsoft ActiveSync version 4.5 or later. Download to personal computer from: http://www.microsoft.com/windowsmobile/en-us/downloads/microsoft/activesync-download.mspx

  Note: Windows Vista and Windows 7 users should download Windows Mobile Device Center version 6.1 or later from the following site, if it is not already loaded on the machine: http://www.microsoft.com/windowsmobile/en-us/downloads/microsoft/device-center-download.mspx

- Trimble Data Transfer Utility (freeware version 2.1 or later). Download to personal computer from: http://www.trimble.com/datatransfer.shtml

3.0 START-UP PROCEDURES

Prior to utilizing the GPS in the field, ensure the unit is fully charged. The unit may come charged from the vendor, but an overnight charge is recommended prior to fieldwork.

The Geo-series GPS units require a docking cradle for both charging and data transfer. The Geo-series GPS unit is docked in the cradle by first inserting the far domed end in the top of the cradled, then gently seating the contact end into the latch. The power charger is then connected to the cradle at the back end using the twist-lock connector. Attach a USB cable as needed between the cradle (B end) and the laptop/PC (A end).

It is recommended that the user also be familiar and check various Windows Mobile settings. One critical setting is the Power Options. The backlight should be set as needed to conserve power when not in use.

3.1 Initial Start Up

1) Power on the GPS unit by pushing the small green button located on the lower right front of the unit.

2) Utilizing the stylus that came with the GPS unit, launch **TerraSync** from the Windows Operating System by tapping on the start icon located in the upper left hand corner of the screen and then tap on **TerraSync** from the drop-down list.

3) If the unit does not default to the Setup screen, tap the Main Menu (uppermost left tab, just below the Windows icon) and select Setup.

4) If the unit was previously shipped to the Pittsburgh office for setup, you can skip directly to Section 4.0. However, to confirm or change settings, continue on to Section 3.1.

3.2 Confirm Setup Settings

Use the Setup section to confirm the TerraSync software settings. To open the Setup section, tap the Main Menu and select Setup. (Note that if the unit was shipped from the Pittsburgh office, these settings should have been set for your specific project. Feel free to contact Pittsburgh staff with any questions.)

1) Tap on the Coordinate System.

2) Verify the project specs are correct for your specific project by scrolling through the various settings. Edit as needed and then tap OK; otherwise, tap Cancel to return to Setup Menu. **Note:** It is always best to utilize the Cancel tab rather than the OK tab if no changes are made since configurations are easily changed by mistake.

3) Tap on the Units.

4) Verify the user preferences are correct for your specific project by scrolling through the various settings. Edit as needed and then tap OK; otherwise, tap Cancel to return to Setup Menu.

5) Tap Real-time Settings.

6) Verify the Real-time Settings are correct for your specific project by scrolling through the various settings. Edit as needed and then tap OK; otherwise, tap Cancel to return to Setup Menu.

7) The GPS unit is now configured correctly for your specific project.

3.3 Antenna Connection

1) If a connection has been properly made with the internal antenna, a satellite icon along with the number of usable satellites will appear at the top of the screen next to the battery icon. If no connection is made (e.g.: no satellite icon), tap on the GPS tab to connect antenna.
2) At this point the GPS unit is ready to begin collecting data.

3.4 Loading a Background file

This section provides instructions on pulling in a pre-loaded background file. These files are helpful in visualizing your current location.

1) From the Main Menu select Map, then tap on Layers, select the background file from drop down list.

2) Select the project-specific background file from the list of available files.

3) Once the selected background file appears, the operator can manipulate the screen utilizing the +/- and <-/-> functions at the bottom of the screen.

4) In operating mode, the operator's location will show up on the background file as a floating "x".

4.0 FIELD DATA COLLECTION

For MRP data collection activities, a new GPS file should be created **every day** and transferred **nightly** using the MRP website (see Section 9.0). This is to insure the timely transfer of data, file organization in the database, and allow for next-day GIS mapping. Also, individual GPS data files should be **unique to a particular site** or unit (typically a UXO number). If multiple sites are visited in a single data, multiple files should be created.

4.1 Creating a Data File

1) From the Main Menu select Data.

2) From the Sub Menu (located below the Data tab) select New which will bring up the New Data File menu.

3) An auto-generated filename appears and should be edited for your specific project. The following naming convention should be followed as closely as possible: **IH-UXO4-01012010-TeamA**, where "IH" is the installation abbreviation (Indian Head), "UXO04" is the site, and "01012010" is the data in MMDDYYYY format. If multiple teams are being deployed across an individual site on the same day, it is important to specify the field team name at the end of the file name ("TeamA"). If the integral keyboard does not appear, tap the small keyboard icon at the bottom of the screen.

4) Select the data dictionary that will be used to collect features. The data dictionary provides predefined fields and drop-down menus to facilitate data collection as it relates to specific MRP data types. The MRP data dictionary is entitled "**MRP Data Collection**" and should appear in the data dictionary drop-down list. This should have been pre-loaded into the GPS prior to use. The data dictionary file is available on the MRP website under the "Reference" section.

5) After entering the file name and selecting the data dictionary, tap Create to create the new file.

6) Confirm antenna height if screen appears. Antenna height is the height that the GPS unit will be held from the ground surface (Typically 3 to 4 feet)

7) The Choose Feature screen appears.

4.2 Collecting Features

1) If not already open, the Collect Feature screen can be opened by tapping the Main Menu and selecting Data. The Sub Menu should default to Collect.

2) **Do not begin the data logging process until you are at the specific location for which you intend to log the data.**

3) A known reference or two should be shot at the beginning and at the end of each day in which the GPS unit is being used. This allows for greater accuracy during post-processing of the data.

4) Upon arriving at the specific location, select the proper feature type from the data dictionary list (MEP Object, Transect End Point, GPS QC Point, or General Point).

5) Tap Create to begin data logging.

6) As the GPS is collecting positions, enter the feature attributes, starting with the Item ID. This field is required and will not allow the user to continue or save the position without entering a value. Enter any additional notes or feature descriptions in the appropriate fields.

7) Data logging can be confirmed by viewing the writing pencil icon in the upper part of the screen. Also, the logging counter will begin. As a Rule of Thumb, accumulate a minimum of 20 readings on the counter, per point, as indicated by the logging counter before saving the GPS data.

8) Once the counter has reached a minimum number of counts (i.e. 20), tap on OK to save the data point to the GPS unit. Confirm the feature. All data points are automatically saved within the GPS unit.

9) Repeat steps 2 through 8, giving each data point a unique name or number.

Note: If the small satellite icon or the pencil icon is blinking, this is an indication the GPS unit is not collecting data. A possible problem may be too few satellites. While still in data collection mode, tap on Main Menu in upper left hand corner of the screen and select Status. Skyplot will display as the default showing the number of available satellites. To increase productivity (number of usable satellites) use the stylus to move the pointer on the productivity and precision line to the left. This will decrease precision, but increase productivity. The precision and productivity of the GPS unit can be adjusted as the number of usable satellites changes throughout the day. To determine if GPS is correctly recording data, see Section 5.2. If the precision toggle is decreased, the user should frequently check the Skyplot display to restore the default values as soon as possible.

4.3 Navigation

This section provides instructions on navigating to saved data points in an existing file within the GPS unit.

1) From the Main Menu select Map.
2) Using the Select tool, pick the point on the map to where you want to navigate.
3) The location you select will have a box placed around the point.
4) From the Options menu, choose the Set Nav Target (aka set navigation target).

5) The location will now have double blue flags indicating this point is you navigation target.
6) From the Main Menu select Navigation.
7) The dial and data on this page will indicate what distance and direction you need to travel to reach the desired target.
8) Follow the navigation guide until you reach the point you select.
9) Repeat as needed for any map point by going back to Step 1.

4.4 Data Quality Control

Quality control checks should be performed each day of data collection and/or data navigation. QC checks are important both to understand real-time accuracy while in the field, and also to provide control data needed during post-processing.

1) Known survey benchmarks, surveyed monitoring wells, or other established and documented control points should be identified

2) GPS equipment should be placed on known control points and positions recorded

3) For data collection tasks - QC check data should be collected at least at the start and completion of the fieldwork for the day of data collection. Additional occupation and collection of control point data should occur as possible during the work day, and should increase in frequency as the number of data points increase and the need for accurate data collection increases

4) For navigation tasks such as stake placement for planned sample locations, QC data checks should be done at least at the start and completion of the fieldwork for each day. Known visible targets should be occupied and observed by the user, while the GPS satellite status and other user interface data is reviewed. The user should assess whether the real-time accuracy settings on the GPS are within the tolerance of the observed visual reference points.

4.5 Viewing Data or Entering Additional Data Points to the Current File

1) To view the stored data points in the current file, tap on the Main Menu and select Map. Stored data points for that particular file will appear. Use the +/- and <-/-> icons in lower left hand corner of screen to zoom in/out and to manipulate current view.

2) To return to data collection, tap on the Main Menu and select Data. You are now ready to continue to collect additional data points.

4.6 Viewing Data or Entering Data Points from an Existing File

1) To view data points from a previous file, tap on Main Menu and select Data, then select File Manager from the Sub Menu.

2) Highlight the file you want to view and select Map from the Main Menu.

3) To add data points to this file, tap on Main Menu and select Data. Continue to collect additional data points.

4.7 Shutting Down

This section provides instruction for properly shutting down the GPS unit.

1) When shutting down the GPS unit for the day, first click on the “X” in the upper right hand corner.
2) You will be prompted to ensure you want to exit TerraSync. Select Yes.
3) Power off the GPS unit by pushing the small green button located on the bottom face of the unit.
4) Place the GPS unit in its cradle to recharge the battery overnight. Ensure the green charge light is visible on the charging cradle.

5.0 DATA TRANSFER

This section describes how data should be downloaded from the GPS units and uploaded to a central website for post-processing and integration into GIS datasets. GPS data collected on a given day should be transferred **that night** for post-processing by GIS staff the next morning. Once post-processed, the GPS data will be plotted on a map and be immediately provided to the project team for review. Data upload, download, and review will be facilitated through a secure MRP website: http://www.ttnus.com/MRPRepository/

5.1 Load Data from the GPS Unit to Your Computer

1) Install the Data Transfer and ActiveSync software installed on your PC (see section 2.2)

2) Connect the GeoXH/XT to your PC via an A/B USB cable (blade end and square end type "HP printer" style)

3) ActiveSync should auto-detect the connection and recognize the data collector

4) Make sure the data file desired is CLOSED in TerraSync prior to transfer

5) Connect via ActiveSync as a guest (not a partnership)

6) Run the Trimble Data Transfer Utility program on your PC

7) Select "***GIS Datalogger on Windows CE***" or similar selection

8) Hit the green connect icon to the right - the far right area should say "***Connected to ....***" if successful

9) Select the "***Receive***" data tab (under device)

10) Select "***Data***" from file types on the right

11) Find the file(s) needed for data transfer. You can sort the data files by clicking on the date/time header

12) Select or browse to a C-drive folder you can put this file for upload

13) When the file appears on the list, hit the "***Transfer All***". Once complete, a packet of multiple data files will appear on your computer in the specified folder.

5.2 Gain Access to MRP Website

1) Confirm that your computer has internet access
2) Click on the following link: http://www.ttnus.com/MRPRepository/
3) To register for the website, click on the "Register here" link. Enter your information and click "Submit." NOTE: Requests for registration are sent to Ralph Basinski, Program Manager, for approval. Please contact mark.maguire@tetratech.com if you experience any access issues.
4) Enter your username (Tetra Tech email address) and password to log in.

5.3 Upload GPS Data from Your Computer to the MRP Website

1) From the main page, select "Upload" from the menu at left.

2) Select the type of data you are uploading, typically "GPS Field Data"

3) Select the appropriate Installation and Site. Remember that GPS files should be unique for each site, even if multiple sites are visited in one day. If collected data is not associated with a site, select "Other."

4) Select “browse” to navigate to the appropriate *.SSF file on your computer. When you use the Trimble download utility to grab data from the GPS unit, multiple files will appear on your computer. You only need to the upload the *.SSF file.

5) Populate the “Comments” field to describe the dataset and any other pertinent information. This information will be provided to the GIS analyst who will be integrating the dataset, so be sure to be as descriptive as possible especially if there are any issues with the data. (For example, if you were to sample 16 points and for some reason you believe only 15 were logged, it is helpful to share this information.)

6) Select “Upload.” Users will be notified if the files were uploaded successfully.

5.4 Download Data from the MRP Website to Your Computer

The download utility on the MRP website will serve different user types. **Field staff** will use the utility to download GIS figures (in PDF format) and view the previous day(s) field data on aerial photographs, checking for any discrepancies or missing data elements. **Project Managers** will also have the ability to download and view these figures, to visualize the data and track project progress. This utility will also allow **GIS Analysts** to download the *.SSF files posted by field staff for post-processing and map plotting.

To download GIS Figures:

1) From the main page, select “Download” from the menu at left.

2) Select an Installation and Site

3) Users can view Figures for a particular date or by a range of dates, by selecting the ` appropriate options. To search all dates, leave all of these fields as the default.

4) Select “Search”

5) A table will appear showing the files available for download. Simply click on the link to the file and you will be prompted to save it to your computer.

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting Tetra Tech NUS, Inc. (TtNUS) field activities.

2.0 SCOPE

Documents presented within this SOP (or equivalents) shall be used for all TtNUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager (PM) - The PM is responsible for obtaining hardbound controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The FOL is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports included in this SOP (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time frame.

General personnel qualifications for field documentation activities include the following:

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

5.0 PROCEDURES

5.1 SITE LOGBOOK

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, record or reference the following activities/events (daily) in the site logbook:

- All field personnel present
- Arrival/departure times and names of site visitors
- Times and dates of health and safety training
- Arrival/departure times of equipment
- Times and dates of equipment calibration

- Start and/or completion of borehole, trench, monitoring well installation activities, etc.
- Daily on-site activities
- Sample pickup information
- Health and safety issues (level of protection, personal protective equipment [PPE], etc.)
- Weather conditions

Maintain a site logbook for each project and initiate it at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Make entries every day that on-site activities take place involving TtNUS or subcontractor personnel. Upon completion of the fieldwork, provide the site logbook to the PM or designee for inclusion in the project's central file.

Record the following information on the cover of each site logbook:

- Project name
- TtNUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, either record the measurements and equipment used in the site logbook or reference the field notebook in which the measurements are recorded (see Attachment A).

Make all logbook, notebook, and log sheet entries in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, cross out the entry with a single strike mark, initial, and date it. At the completion of entries by any individual, the logbook pages used must be signed and dated by the person making the entries. The site logbook must also be signed by the FOL at the end of each day.

5.1.2 Photographs

Sequentially number movies, slides, or photographs taken of a site or any monitoring location to correspond to logbook/notebook entries. Enter the name of the photographer, date, time, site location, site description, and weather conditions in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided because they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend on the subject matter, type of camera (digital or film), and the processing it requires. Follow chain-of-custody procedures for film used for aerial photography, confidential information, or criminal investigation. After processed, consecutively number the slides of photographic prints and label them according to the logbook/notebook descriptions. Docket the site photographs and associated negatives and/or digitally saved images to compact disks into the project's central file.

5.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a

separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 FIELD FORMS

All TtNUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs, subject to client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOPs.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample log sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. Complete a sample log sheet for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Complete the required information on the adhesive labels and apply them to every sample container. Obtain sample labels from the appropriate program/project source, request that they be electronically generated in house, or request them the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record

The chain-of-custody record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used as follows for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site:

- Retain one carbonless copy of the completed chain-of custody form in the field.
- Send one copy is sent to the PM (or designee)
- Send the original to the laboratory with the associated samples. Place the original (top, signed copy) of the chain-of custody form inside a large Ziploc®-type bag taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one chain-of custody form, send the form with the cooler containing vials for volatile organic compound (VOC) analysis or the cooler with the air bill attached. Indicate on the air bill how many coolers are included with that shipment.

An example of a chain-of-custody form is provided as Attachment C. After the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed chain-of custody form (any discrepancies between the sample labels and chain-of custody form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the TtNUS PM). The chain-of custody form is signed and copied. The laboratory will retain the copy, and the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label that is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. Sign and date custody seals

and affix them across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). Obtain custody seals from the laboratory (if available) or purchase them from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Complete Field Analytical Log Sheets to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

Complete a Groundwater Level Measurement Sheet for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. Use a Pumping Test Data Sheet to facilitate this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be established in advance.

5.3.2.3 Packer Test Report Form

Complete a Packer Test Report Form for each well at which a packer test is conducted.

5.3.2.4 Boring Log

Complete a Summary Log of Boring, or Boring Log for each soil boring performed to document the materials encountered, operation and driving of casing, and locations/depths of samples collected. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a photoionization detector [PID] or flame ionization detector [FID]), enter these readings on the boring log at the appropriate depth. When they become available, enter the laboratory sample number, concentrations of key contaminants, or other pertinent information in the "Remarks" column. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

Complete a Monitoring Well Construction Details Form for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Miscellaneous monitoring well forms that may be required on a project-specific basis include the Monitoring Well Materials Certificate of Conformance and Monitoring Well Development Record. Use a Monitoring Well Materials Certificate of Conformance to document all materials utilized during each monitoring well installation. Use a Monitoring Well Development Record to document all well development activities.

5.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Miscellaneous field forms/checklists forms that may be required on a project-specific basis include the following:

- Container Sample and Inspection Sheet – use this form when a container (drum, tank, etc.) is sampled and/or inspected.
- QA Sample Log Sheet – use this form when a QA sample such as an equipment rinsate blank, source blank, etc. is collected.
- Field Task Modification Request (FTMR) – use this form to document deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Maintain copies of all FTMRs with the on-site planning documents, and place originals in the final evidence file.
- Field Project Daily Activities Checklist and Field Project Pre-Mobilization Checklist – used these during both the planning and field effort to ensure that all necessary tasks are planned for and completed. These two forms are not requirements but are useful tools for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure the proper operation and response of the equipment, to document the accuracy, precision, or sensitivity of the measurements, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log, which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. Maintain an Equipment Calibration Log for each electronic measuring device used in the field; make entries for each day the equipment is used or in accordance with manufacturer recommendations.

5.4 FIELD REPORTS

The primary means of recording on-site activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation but are not easily used for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain on site for extended periods of time and are thus not accessible for timely review by project management. Other reports useful for tracking and reporting the progress of field activities are described below.

5.4.1 Daily Activities Report

To provide timely oversight of on-site contractors, complete and submit Daily Activities Reports (DARs) as described below.

5.4.1.1 Description

The DAR documents the activities and progress for each day's field work. Complete this report on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring that involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the DAR to the FOL for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DARs are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the PM.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

In addition to those described herein, other summary reports may also be contractually required.

All TtNUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF FIELD FORMS ON THE TtNUS INTRANET SITE

- Boring Log
- Container Sample and Inspection Sheet
- Daily Activities Checklist
- Daily Activities Record
- Equipment Calibration Log
- Field Task Modification Request
- Field Analytical Log sheet - Geochemical Parameters
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Hydraulic Conductivity Test Data Sheet
- Low Flow Purge Data Sheet
- Bedrock Monitoring Well Construction (Stick Up)
- Bedrock Monitoring Well Construction Flush Mount
- Bedrock Monitoring Well Construction Open Hole
- Confining Layer Monitoring Well Construction
- Monitoring Well Development Record

- Monitoring Well Materials Certificate of Conformance
- Overburden Monitoring Well Construction Flush Mount
- Overburden Monitoring Well Construction Stick Up
- Packer Test Report Form
- Pumping Test Data Sheet
- QA Sample Log Sheet
- Soil/Sediment Sample Log Sheet
- Surface Water Sample Log Sheet
- Test Pit Log
- Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B
SAMPLE LABEL

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:		
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:	Laboratory:		

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER 3413 | PAGE ____ OF _____

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS										COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date	**Date**
Signature	**Signature**

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1.0 PURPOSE

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

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

2.0 SCOPE

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

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

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

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

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

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

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

5.0 PROCEDURES

5.1 INTRODUCTION

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

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

Additional segments may be added as needed. For example:

(1) Soil and sediment sample ID

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

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

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

(3) Biota sample ID

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

5.2 SAMPLE IDENTIFICATION FIELD REQUIREMENTS

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

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

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

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

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

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

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

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

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

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

5.3 EXAMPLE SAMPLE FIELD DESIGNATIONS

Examples of each of the fields are as follows:

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

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

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

Sample type - Examples of sample types are as follows:

AH - Ash Sample

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

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

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

Species identifier - Examples of species identifier are as follows:

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

5.4 EXAMPLES OF SAMPLE NOMENCLATURE

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

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

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

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

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

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

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

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

5.5 FIELD QA/QC SAMPLE NOMENCLATURE

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

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

The QC types are identified as:

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

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

5.6 EXAMPLES OF FIELD QA/QC SAMPLE NOMENCLATURE

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

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

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

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

6.0 DEVIATIONS

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

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1.0 PURPOSE

The purpose of this guideline is to provide a general description of, and technical management guidance on, the use of Ground-Penetrating Radar (GPR) Surveys.

2.0 SCOPE

This guideline provides a description of the principles of operation, instrumentation, applicability and implementability of standard GPR methods used during site investigations, to determine subsurface stratigraphic and other interfaces discernable by GPR. The document is intended to be used by the Project Manager (PM), Field Operations Leader (FOL), or site geophysicist to develop an understanding of each method sufficient to permit work planning, scheduling, and resource planning. This guidance is not intended to provide a detailed description of methodology and operation. The highly specialized nature of GPR surveys requires inclusion of project-specific, site-specific, and subcontractor-specific information prior to development of detailed operating plans, during both planning and execution.

3.0 GLOSSARY

Dielectric Constant. Property of a medium that determines reflection, absorption, and transmission characteristics of a radar signal; a measure of the ability of a material to store charge when an electric field is applied. Also known as permittivity.

Depth of Investigation. The depth at which an object of interest can be detected in a GPR survey.

Radar Trace. A display of reflected signal strength on a graph of lateral distance along the ground versus the radar signal travel time (corresponding to vertical distance of penetration).

Two-Way Travel Time. The time required for a radar signal to travel from the antenna to a target and return to the antenna. Travel time is a function of the depth of an object and the dielectric constant (permittivity) of the medium (soil, rock, etc.).

4.0 RESPONSIBILITIES

Project Manager - Responsible for scoping of the ground-penetrating radar surveys during development of the Work Plan, with input from the FOL, site geophysicist, and site geologist.

Field Operations Leader (FOL) - Responsible for overall management and coordination of the field work.

Site Geophysicist - As a specialist in this field, the site geophysicist plays a central role in determining the appropriateness of this technique for providing necessary data. Field work for these surveys is supervised by the site geophysicist, with support from geophysical technical specialists and other personnel (i.e., site geologist) as needed. Data reduction and interpretation are performed by the site geophysicist or technical specialist.

5.0 PROCEDURES

5.1 Description of Methods

5.1.1 Theory and Principles of Operation

Commercially-available GPR units operate on the principle of time-domain reflectometry, in which the difference in strength and the time delay between a transmitted electromagnetic pulse and its reflection

from an object are measured. The time delay or two-way travel time, t, is directly related to the propagation velocity of the electromagnetic waves, v, and to the distance between the transmitter and the object, D, as follows:

$$t = \frac{2D}{v}$$

Because GPR is normally used at or near the surface of the ground, the distance D corresponds to the depth of buried target(s) that reflect the radar signals.

The strength of a radar signal is a complex function of the distance traveled through the medium and the dielectric constant, the magnetic permeability, and the electrical conductivity of the medium. Radar signals are attenuated rapidly in materials with high dielectric constants. This attenuation in subsurface media is a function of the mineralogy and the water content. Thus, materials such as dry sands and gravels are least absorptive of radar signals, whereas wet clays are highly absorptive. The absorptive properties of the medium limits the depth of investigation, e.g., the depth at which targets can be detected.

Radar antennas are available which operate at frequencies centered on 25-900 MHz. Whereas the higher frequencies are able to detect smaller targets, the penetration depth is roughly inversely proportional to frequency. Thus, any GPR survey requires an analysis of the trade-off between resolution and depth of penetration so that the optimal frequency can be selected.

The amplitude of a radar reflection is a function of the composition, size shape, and depth of the target and contrast between permittivity of target and permittivity of surrounding material. High amplitude reflections are from objects exhibiting large differences in dielectric constant from the surrounding medium, and are large in size compared to the radar signal wave length.

5.1.2 General Applicability

GPR signals are reflected from any interface which corresponds to an abrupt change in dielectric constant. Therefore, both metallic and nonmetallic objects (including voids) as well as changes in geologic structure can be detected by this method. Because of the higher frequencies used, target resolution is considerably improved over seismic or resistivity sounding methods. However, the high frequencies also result in strong attenuation of the signals, particularly in clay materials with high moisture content. At 100 MHz, the depth of investigation in clay soil with 20 percent moisture content is 3 feet or less, whereas in dry clay, or a sand with 20 percent moisture, the penetration depth can extend to approximately 30 feet.

GPR can be a powerful method for locating and mapping buried drums, wooden objects, foundations, non-containerized wastes, underground utilities, and many other artifacts (including historical artifacts) at a site. Depending on whether sufficient depth of investigation can be achieved, the method can also be used to map saturated zones and bedrock contours, and locate sinkholes or fracture systems.

A major limitation to applicability is the degree of subjective interpretation that is employed. The problem of noting a small signal disturbance in a sea of clutter can be overcome somewhat by simultaneous observation of a large number of parallel tracks.

5.1.3 Instrumentation

The standard array of GPR instrumentation consists of a transmitter/antenna unit which is pulled along the ground; a control unit, containing a power supply and signal processing circuitry which is connected to the antenna by a cable; and a laptop computer or analog tape recorder. The system can be vehicle-

mounted, and the transmitter can be connected via radio link to the signal processing and recording equipment.

5.2 Data Acquisition

5.2.1 Field Procedures

GPR surveys are performed by establishing a grid of parallel survey lines across the site and moving the radar antenna along each of these lines. A suitable means must be provided for determining the location of the radar unit along each of the lines, and for documenting this information on the recording medium. Typical systems measure the time and velocity of antenna motion, or determine the position of the antenna by synchronization signals from the wheels or tracks of the vehicle used to tow the antenna.

To determine the depth of anomalies noted on radar traces, it is necessary to convert the travel time data that are actually recorded. The velocity of electromagnetic waves in the subsurface medium at the site is determined by excavation to observed targets and measuring their depths. The velocity should be determined at several points in the area of interest. Depths to targets can be estimated by using published values of dielectric constants for a range of different earthen materials and the following formula:

$$D = \frac{ct}{2\sqrt{\varepsilon_r}} = \frac{V_m t}{2} \qquad V_m = \frac{c}{\sqrt{\varepsilon_r}}$$

Where:

D = depth to target (feet)
t = two-way travel time (nanoseconds)
c = velocity of light (1 foot/nanosecond)
ε_r = dielectric constant (dimensionless)
V_m = velocity of electromagnetic waves

Two-way travel times can also be calculated by collecting GPR data over targets of known depth (e.g., trenches, buried pipes/culverts).

Specific procedures for data acquisition are as follows:

1. The time scale of the GPR unit shall be checked 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 ($3x10^8$ m/sec.). 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)

2. Prior to conducting a survey, a GPR traverse should be conducted 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 (V) in soil can be calculated from the following equation:

$$V = 2d/t$$

3. A short GPR traverse shall be repeated twice daily over a known feature prior to and after conducting daily operations. Technical judgment shall be exercised to ensure that variations between repeat readings are a result of changing soil conditions rather than the electronics.

5.2.2 Data Format

Reflected radar signals are electronically processed and displayed as an intensity-modulated time spectrum, where the time corresponds to target depth as described above. The series of signals corresponding to the reflected pulses as the antenna moves along a path forms a three-dimensional data set containing distance of traverse, depth, and intensity information.

Typically, the data are recorded on a personal computer with distance displayed along the X-axis, time (depth) displayed along the Y-axis, and the intensity given by the degree of amplitude of the reflection. In a typical survey, a series of parallel tracks are traversed by the GPR, and the series of resulting oscillograph traces provides XYZ locational information and intensity of reflection from targets of interest.

Although much of the data obtained in a GPR survey is automatically recorded by the instrument, additional information to identify and interpret each trace should be recorded in a field notebook or on log sheets. At a minimum the data records should contain the following information:

1. Project name, number and location.
2. Company or organization.
3. Date and time of day.
4. Operator's name.
5. Line and trace designation (also recorded directly on the signal recording medium).
6. Equipment serial numbers.
7. Antenna frequency.
8. Direction and speed of antenna movement.
9. Weather and temperature.
10. Site map coordinates at the beginning and end of the trace.
11. Notes, remarks or comments.
12. Electromagnetic velocity in the subsurface medium at the nearest calibration point.

5.3 Data Interpretation

Except for those systems which provide extensive data processing, interpretation of anomalies in GPR traces require considerable subjective evaluation by a trained geophysicist. Extensive experience is essential to distinguish target reflections from inherent system noise and interferences. In many cases, the anomalies due to targets of interest are small compared to varying reflections from the antenna system, the ground surface, geologic perturbations, and other interferences. Similarly, an acceptable interpretation of target depth from travel time data requires a knowledge of geophysical characteristics across the site.

A radar antenna transmits a "cone," rather than a thin beam of electromagnetic energy, so that reflections are obtained from objects not directly below the antenna. As the antenna moves across the plane of an object, reflections are obtained for a considerable distance along the antenna path. The signal travel times will vary during this process, corresponding to the distance between the antenna and the object. A discrete spherical target would exhibit a hyperbolic reflection pattern on the radar trace, with the apex of

the hyperbola corresponding to the location and depth of the object. Multiple or odd-shaped targets, or targets of considerable size (compared to the radar wavelength) will exhibit complex reflection patterns consisting of overlapping hyperbolas. Thus, a true "picture" of subsurface objects is not obtained, and experience is necessary to translate the complex tracings into information indicating the target depth, size, and shape.

5.4 Applications Management

5.4.1 Prerequisites

Appropriate planning of GPR surveys requires at least a basic understanding of the geophysical characteristics of the site. The type and structure of soils and geologic formations should be known. A description of the site should include the depth, size, shape, and type of potential targets to be detected, as well as obstructive site features such as rough or wet terrain and underground utilities and/or structures. The existence of, and depth to known buried objects should be listed and mapped. Other specifications include the degree of locational resolution desired, probable weather conditions during site activities, and the type and sophistication of software required for data interpretation and presentation.

5.4.2 Work Planning and Scheduling

If possible, GPR surveys should be performed concurrently with other geophysical surveys. Radar data complement information from other geophysical methods such as seismic refraction, magnetometry, and resistivity in arriving at an interpretation of subsurface geohydrologic features and location of buried waste materials. This information is important in locating and selecting the appropriate type of monitoring wells.

The time and effort required to perform GPR surveys vary greatly depending on the sophistication of the available equipment and the complexity of the site. Assuming a 2-person team, simple hand-operated radar systems can cover from 1/4 to 1/2 acre per day, proper documentation, and simple interpretation. Vehicle-mounted systems with automatic data recording and processing can cover from 2 to 5 acres per day. Sophisticated data processing, detailed interpretations, and high-quality displays require considerable computer usage and approximately twice the time required for the actual field survey.

The specific objectives of the GPR survey should be defined in the Work Plan and should include the following elements:

1. Type of survey (level of detail) to be accomplished, and area to be covered.
2. Type, depth, size, and composition of targets of interest (if known).
3. Locational accuracy required.
4. Schedule limitations.
5. Degree of sophistication required for data presentation and interpretation.
6. Specific deliverables required.

5.5 Quality Control (QC)

5.5.1 General

Because of the specialized nature of the method and the highly subjective interpretations needed to process the data, GPR surveys are subject to misapplication, erroneous interpretation, and collection of inadequate or incomplete data. This susceptibility to misuse requires that an adequate quality control program be established. Quality control aspects include the following :

- Insistence on a defined scope of work, specifications, and data validation procedures.

- No data point should be rejected from a data set without appropriate justification; field data sheets should contain all observed data and the conditions that could impact data validation.

- All field data should be recorded in permanent ink in a bound field logbook, and each page signed and dated by the operator. The original unaltered field logbook should be retained in the project file.

- In general, the objectives of geophysical surveys can be met by relative measurements across an area or with depth. Absolute calibration is therefore of lesser importance than precision of measurements. However, a properly calibrated instrument provides an added measure of data validity and permits correlation and comparison of the associated data with site features and hydrogeologic characteristics not evident at the time of the field effort.

- An evaluation should be made of background noise, interferences, and obstructions at a site. These items should be recorded in the field logbook. These real-time quality control procedures aid field personnel in correction of noise sources over which they have control, in validating suspected external sources, and in early detection of problems that may jeopardize the survey results.

5.5.2 Daily Quality Control

All radar traces and interpreted data sets should be accompanied by quality control data that indicate the level of quality of the data. Periodic replicate measurements should be made so that measurement precision can be established. Time and/or depth calibrations should be performed on a daily basis.

A calibration that yields significant changes in instrument parameters or travel time may indicate the need for repetition of data or increased density of travel time calibrations in the area of interest. Graphical data should be reviewed during the field activities to determine that data quality is adequate, and whether the survey results appear to be consistent with geophysical conceptual model of the site.

5.6 Potential Problems

A wide variety of problems may be encountered during performance of a GPR survey. Problems can be expected to arise in the following areas:

5.6.1 Planning and Execution

Rarely is a GPR survey accomplished exactly according to the original plan. Site features not previously specified and other variations can occur that force changes in the details of the approach. However, the objectives of the survey, the general methodology, the amount and quality of data required, and the degree of data interpretation requested should remain unchanged. Project work scopes should be written with some degree of latitude to allow a change in plans whenever justified.

5.6.2 Noise and Interferences

Measurements can be affected severely by natural and by man-made sources of interference. Sources of system noise that degrade the quality of radar traces include improper spacing of antennas above ground, improper cable placement, location of antennas too close to other system components, and faulty instrument operation. Because reflections are obtained from any objective with a dielectric constant differing from the surroundings, large masses or high density of buried or surface rocks, metal, debris, wet soil, or structures can mask targets of interest. Some antennas are not shielded on top, and similar interfering reflections will be obtained from overhead objects such as trees, power lines and buildings.

The site personnel must recognize the limitations posed by these obstructions, and take steps to minimize these interferences.

Topographic and geologic features can also interfere with acquisition of high-quality target detection data. Small depressions in the ground surface, the presence of boulders, clay lenses and moist soil zones affect both the detectability of a target and determination of its depth from the travel time.

Sources of electromagnetic energy in the vicinity, such as radio or television transmitters, or navigational radar antennas can result in spurious signals in the radar traces. In some cases, these problems can be minimized by judicious selection of radar and/or data communications frequency, and by scheduling the surveys during periods of transmission inactivity.

5.6.3 Weather Conditions

Because water is a good absorber of radar signals, wet weather has a very serious effect on the ability to perform GPR surveys. Physical difficulties in executing a survey over wet terrain also may be expected. The field activities should be planned, if possible, during periods when dry weather is expected. Schedules for surveys should account for the probability that moist soil conditions will exist.

5.6.4 Technical Difficulties

Preventable difficulties include equipment malfunction, or misapplication, poor operator training, and lack of applications experience. Other difficulties may arise because the geophysical character of the site is not as initially conceptualized. The effect of these problems can be minimized by early recognition, using responsive and responsible technical management. Interim, real-time scrutiny of the data by the site geophysicist and management personnel is essential. The site geophysicist or geophysical subcontractor must be responsive regarding equipment replacement, repair, or changes in personnel. The Project Manager and the FOL should be cognizant of technical difficulties beyond the control of the field personnel, and should recognize the need to change plans, change performers, or cancel a survey, as appropriate.

6.0 REFERENCES

Good discussions of various geophysical survey techniques and applications are found in the following references:

1. Benson, Richard C., Robert A. Glaccum and Michael R. Noel, Geophysical Techniques for Sensing Buried Wastes and Waste Migration. U.S. EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

2. Costello, Robert L., 1980, Identification and Description Geophysical Techniques, Report No. DRXTH-TE-CR-80084, U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland; Defense Technical Information System Number ADA 123939.

3. McKown G. L., G. A. Sandness and G. W. Dawson, Detection and Identification of Buried Waste and Munitions, Proceedings of the 11th American Defense Preparedness Association Environmental Systems Symposium, Arlington, Virginia.

7.0 RECORDS

The following information will be recorded in the field logbook.

- Date
- Type of equipment
- Name and project number of site
- Site conditions that may affect data collection
- Depth and location information regarding known targets used for determining the wave velocity
- Additional items mentioned in Section 5.2.2

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1.0 PURPOSE

Utilities such as electric service lines, natural or propane gas lines, water and sewage lines, telecommunications, and steam lines are very often in the immediate vicinity of work locations. Contact with underground or overhead utilities can have serious consequences including employee injury/fatality, property and equipment damage, substantial financial impacts, and loss of utility service to users.

The purpose of this procedure is to provide minimum requirements and technical guidelines regarding the appropriate procedures to be followed when performing subsurface and overhead utility locating services. It is the policy of Tetra Tech NUS, Inc. (TtNUS) to provide a safe and healthful work environment for the protection of our employees. The purpose of this Standard Operating Procedure (SOP) is to aid in achieving the objectives of this policy, to present the acceptable procedures pertaining to utility locating and excavation clearance activities, and to present requirements and restrictions relevant to these types of activities. This SOP must be reviewed by any employee potentially involved with underground or overhead utility locating and avoidance activities.

2.0 SCOPE

This procedure applies to all TtNUS field activities where there may be potential contact with underground or overhead utilities. This procedure provides a description of the principles of operation, instrumentation, applicability, and implementability of typical methods used to determine the presence and avoidance of contact with utility services. This procedure is intended to assist with work planning and scheduling, resource planning, field implementation, and subcontractor procurement. Utility locating and excavation clearance requires site-specific information prior to the initiation of any such activities on a specific project. This SOP is not intended to provide a detailed description of methodology and instrument operation. Specialized expertise during both planning and execution of several of the methods presented may also be required.

3.0 GLOSSARY

Electromagnetic Induction (EMI) Survey - A geophysical exploration method whereby electromagnetic fields are induced in the ground and the resultant secondary electromagnetic fields are detected as a measure of ground conductivity.

Magnetometer – A device used for precise and sensitive measurements of magnetic fields.

Magnetic Survey – A geophysical survey method that depends on detection of magnetic anomalies caused by the presence of buried ferromagnetic objects.

Metal Detection – A geophysical survey method that is based on electromagnetic coupling caused by underground conductive objects.

Vertical Gradiometer – A magnetometer equipped with two sensors that are vertically separated by a fixed distance. It is best suited to map near surface features and is less susceptible to deep geologic features.

Ground Penetrating Radar – Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture.

4.0 RESPONSIBILITIES

Project Manager (PM)/Task Order Manager (TOM) - Responsible for ensuring that all field activities are conducted in accordance with this procedure.

Site Manager (SM)/Field Operations Leader (FOL) - Responsible for the onsite verification that all field activities are performed in compliance with approved SOPs or as otherwise directed by the approved project plan(s).

Site Health & Safety Officer (SHSO) – Responsible to provide technical assistance and verify full compliance with this SOP. The SHSO is also responsible for reporting any deficiencies to the Corporate Health and Safety Manager (HSM) and to the PM/TOM.

Health & Safety Manager (HSM) – Responsible for preparing, implementing, and modifying corporate health and safety policy and this SOP.

Site Personnel – Responsible for performing their work activities in accordance with this SOP and the TtNUS Health and Safety Policy.

5.0 PROCEDURES

This procedure addresses the requirements and technical procedures that must be performed to minimize the potential for contact with underground and overhead utility services. These procedures are addressed individually from a buried and overhead standpoint.

5.1 Buried Utilities

Buried utilities present a heightened concern because their location is not typically obvious by visual observation, and it is common that their presence and/or location is unknown or incorrectly known on client properties. This procedure must be followed prior to beginning any subsurface probing or excavation that might potentially be in the vicinity of underground utility services. In addition, the Utility Clearance Form (Attachment 3) must be completed for every location or cluster of locations where intrusive activities will occur.

Where the positive identification and de-energizing of underground utilities cannot be obtained and confirmed using the following steps, the PM/TOM is responsible for arranging for the procurement of a qualified, experienced, utility locating subcontractor who will accomplish the utility location and demarcation duties specified herein.

1. A comprehensive review must be made of any available property maps, blue lines, or as-builts prior to site activities. Interviews with local personnel familiar with the area should be performed to provide additional information concerning the location of potential underground utilities. Information regarding utility locations shall be added to project maps upon completion of this exercise.

2., A visual site inspection must be performed to compare the site plan information to actual field conditions. Any findings must be documented and the site plan/maps revised. The area(s) of proposed excavation or other subsurface activities must be marked at the site in white paint or pin flags to identify those locations of the proposed intrusive activities. The site inspection should focus on locating surface indications of potential underground utilities. Items of interest include the presence of nearby area lights, telephone service, drainage grates, fire hydrants, electrical service vaults/panels, asphalt/concrete scares and patches, and topographical depressions. Note the location of any emergency shut off switches. Any additional information regarding utility

locations shall be added to project maps upon completion of this exercise and returned to the PM/TOM.

3. If the planned work is to be conducted on private property (e.g., military installations, manufacturing facilities, etc.) the FOL must identify and contact appropriate facility personnel (e.g., public works or facility engineering) before any intrusive work begins to inquire about (and comply with) property owner requirements. It is important to note that private property owners may require several days to several weeks advance notice prior to locating utilities.

4. If the work location is on public property, the state agency that performs utility clearances must be notified (see Attachment 1). State "one-call" services must be notified prior to commencing fieldwork per their requirements. Most one-call services require, by law, 48- to 72-hour advance notice prior to beginning any excavation. Such services typically assign a "ticket" number to the particular site. This ticket number must be recorded for future reference and is valid for a specific period of time, but may be extended by contacting the service again. The utility service will notify utility representatives who then mark their respective lines within the specified time frame. It should be noted that most military installations own their own utilities but may lease service and maintenance from area providers. Given this situation, "one call" systems may still be required to provide location services on military installations.

5. Utilities must be identified and their locations plainly marked using pin flags, spray paint, or other accepted means. The location of all utilities must be noted on a field sketch for future inclusion on project maps. Utility locations are to be identified using the following industry-standard color code scheme, unless the property owner or utility locator service uses a different color code:

white	excavation/subsurface investigation location
red	electrical
yellow	gas, oil, steam
orange	telephone, communications
blue	water, irrigation, slurry
green	sewer, drain

6. Where utility locations are not confirmed with a high degree of confidence through drawings, schematics, location services, etc., the work area must be thoroughly investigated prior to beginning the excavation. In these situations, utilities must be identified using safe and effective methods such as passive and intrusive surveys, or the use of non-conductive hand tools. Also, in situations where such hand tools are used, they should always be used in conjunction with suitable detection equipment, such as the items described in Section 6.0 of this SOP. Each method has advantages and disadvantages including complexity, applicability, and price. It also should be noted that in some states, initial excavation is required by hand to a specified depth.

7. At each location where trenching or excavating will occur using a backhoe or other heavy equipment, and where utility identifications and locations cannot be confirmed prior to groundbreaking, the soil must be probed using a device such as a tile probe which is made of non-conductive material such as fiberglass. If these efforts are not successful in clearing the excavation area of suspect utilities, hand shoveling must be performed for the perimeter of the intended excavation.

8. All utilities uncovered or undermined during excavation must be structurally supported to prevent potential damage. Unless necessary as an emergency corrective measure, TtNUS shall not make any repairs or modifications to existing utility lines without prior permission of the utility owner, property owner, and Corporate HSM. All repairs require that the line be locked-out/tagged-out prior to work.

5.2 Overhead Power Lines

If it is necessary to work within the minimum clearance distance of an overhead power line, the overhead line must be de-energized and grounded, or re-routed by the utility company or a registered electrician. If protective measures such as guarding, isolating, or insulating are provided, these precautions must be adequate to prevent employees from contacting such lines directly with any part of their body or indirectly though conductive materials, tools, or equipment.

The following table provides the required minimum clearances for working in proximity to overhead power lines.

Nominal Voltage	Minimum Clearance
0 -50 kV	10 feet, or one mast length; whichever is greater
50+ kV	10 feet plus 4 inches for every 10 kV over 50 kV or 1.5 mast lengths; whichever is greater

6.0 UNDERGROUND LOCATING TECHNIQUES

A variety of supplemental utility locating approaches are available and can be applied when additional assurance is needed. The selection of the appropriate method(s) to employ is site-specific and should be tailored to the anticipated conditions, site and project constraints, and personnel capabilities.

6.1 Geophysical Methods

Geophysical methods include electromagnetic induction, magnetics, and ground penetrating radar. Additional details concerning the design and implementation of electromagnetic induction, magnetics, and ground penetrating radar surveys can be found in one or more of the TtNUS SOPs included in the References (Section 8.0).

Electromagnetic Induction

Electromagnetic Induction (EMI) line locators operate either by locating a background signal or by locating a signal introduced into the utility line using a transmitter. A utility line acts like a radio antenna, producing electrons, which can be picked up with a radiofrequency receiver. Electrical current carrying conductors have a 60HZ signal associated with them. This signal occurs in all power lines regardless of voltage. Utilities in close proximity to power lines or used as grounds may also have a 60HZ signal, which can be picked up with an EM receiver. A typical example of this type of geophysical equipment is an EM-61.

EMI locators specifically designed for utility locating use a special signal that is either indirectly induced onto a utility line by placing the transmitter above the line or directly induced using an induction clamp. The clamp induces a signal on the specific utility and is the preferred method of tracing since there is little chance of the resulting signals being interfered with. A good example of this type of equipment is the Schonstedt® MAC-51B locator. The MAC-51B performs inductively traced surveys, simple magnetic locating, and traced nonmetallic surveys.

When access can be gained inside a conduit to be traced, a flexible insulated trace wire can be used. This is very useful for non-metallic conduits but is limited by the availability of gaining access inside the pipe.

Magnetics

Magnetic locators operate by detecting the relative amounts of buried ferrous metal. They are incapable of locating or identifying nonferrous utility lines but can be very useful for locating underground storage tanks (UST's), steel utility lines, and buried electrical lines. A typical example of this type of equipment is the Schonstedt® GA-52Cx locator. The GA-52Cx is capable of locating 4-inch steel pipe up to 8 feet deep.

Non-ferrous lines are often located by using a typical plumbing tool (snake) fed through the line. A signal is then introduced to the snake that is then traced.

Ground Penetrating Radar

Ground Penetrating Radar (GPR) involves specialized radar equipment whereby a signal is sent into the ground via a transmitter. Some portion of the signal will be reflected from the subsurface material, which is then recorded with a receiver and electronically converted into a graphic picture. In general, an object which is harder than the surrounding soil will reflect a stronger signal. Utilities, tunnels, UST's, and footings will reflect a stronger signal than the surrounding soil. Although this surface detection method may determine the location of a utility, this method does not specifically identify utilities (i.e., water vs. gas, electrical vs. telephone); hence, verification may be necessary using other methods. This method is somewhat limited when used in areas with clay soil types or with a high water table.

6.2 Passive Detection Surveys

Acoustic Surveys

Acoustic location methods are generally most applicable to waterlines or gas lines. A highly sensitive Acoustic Receiver listens for background sounds of water flowing (at joints, leaks, etc.) or to sounds introduced into the water main using a transducer. Acoustics may also be applicable to determine the location of plastic gas lines.

Thermal Imaging

Thermal (i.e., infrared) imaging is a passive method for detecting the heat emitted by an object. Electronics in the infrared camera convert subtle heat differentials into a visual image on the viewfinder or a monitor. The operator does not look for an exact temperature; rather they look for heat anomalies (either elevated or suppressed temperatures) characteristic of a potential utility line.

The thermal fingerprint of underground utilities results from differences in temperature between the atmosphere and the fluid present in a pipe or the heat generated by electrical resistance. In addition, infrared scanners may be capable of detecting differences in the compaction, temperature and moisture content of underground utility trenches. High-performance thermal imagery can detect temperature differences to hundredths of a degree.

6.3 Intrusive Detection Surveys

Vacuum Excavation

Vacuum excavation is used to physically expose utility services. The process involves removing the surface material over approximately a 1' x 1' area at the site location. The air-vacuum process proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting

debris. This process ensures the integrity of the utility line during the excavation process, as no hammers, blades, or heavy mechanical equipment comes into contact with the utility line, eliminating the risk of damage to utilities. The process continues until the utility is uncovered. Vacuum excavation can be used at the proposed site location to excavate below the "utility window" which is usually 8 feet.

Hand Excavation

When the identification and location of underground utilities cannot be positively confirmed through document reviews and/or other methods, borings and excavations may be cleared via the use of non-conductive hand tools. This should always be done in conjunction with the use of detection equipment. This would be required for all locations where there is a potential to impact buried utilities. The minimum hand-excavation depth that must be reached is to be determined considering the geographical location of the work site. This approach recognizes that the placement of buried utilities is influenced by frost line depths that vary by geographical region. Attachment 2 presents frost line depths for the regions of the contiguous United States. At a minimum, hand excavation depths must be at least to the frost line depth (see Attachment 2) plus two (2) feet, but never less than 4 feet below ground surface (bgs). For hand excavation, the hole created must be reamed large enough to be at least the diameter of the drill rig auger or bit prior to drilling. For soil gas surveys, the survey probe shall be placed as close as possible to the cleared hand excavation. It is important to note that a post-hole digger must not be used in this type of hand excavation activity.

Tile Probe Surveys

For some soil types, site conditions, and excavation requirements, non-conductive tile probes may be used. A tile probe is a "T"-handled rod of varying lengths that can be pushed into the soil to determine if any obstructions exist at that location. Tile probes constructed of fiberglass or other nonconductive material are readily-available from numerous vendors. Tile probes must be performed to the same depth requirements as previously specified. As with other types of hand excavating activities, the use of a non-conductive tile probe, should always be in conjunction with suitable utility locating detection equipment.

7.0 INTRUSIVE ACTIVITIES SUMMARY

The following list summarizes the activities that must be performed prior to beginning subsurface activities:

1. Map and mark all subsurface locations and excavation boundaries using white paint or markers specified by the client or property owner.

2. Notify the property owner and/or client that the locations are marked. At this point, drawings of locations or excavation boundaries shall be provided to the property owner and/or client so they may initiate (if applicable) utility clearance.

   Note: Drawings with confirmed locations should be provided to the property owner and/or client as soon as possible to reduce potential time delays.

3. Notify "One Call" service. If possible, arrange for an appointment to show the One Call representative the surface locations or excavation boundaries in person. This will provide a better location designation to the utilities they represent. You should have additional drawings should you need to provide plot plans to the One Call service.

4. Implement supplemental utility detection techniques as necessary and appropriate to conform utility locations or the absence thereof.

5. Complete Attachment 3, Utility Clearance Form. This form should be completed for each excavation location. In situations where multiple subsurface locations exist within the close proximity of one another, one form may be used for multiple locations provided those locations are noted on the Utility Clearance Form. Upon completion, the Utility Clearance Form and revised/annotated utility location map becomes part of the project file.

8.0 REFERENCES

OSHA Letter of Interpretation, Mr. Joseph Caldwell, Attachment 4
OSHA 29 CFR 1926(b)(2)
OSHA 29 CFR 1926(b)(3)
TtNUS Utility Locating and Clearance Policy
TtNUS SOP GH-3.1; Resistivity and Electromagnetic Induction
TtNUS SOP GH-3.2; Magnetic and Metal Detection Surveys
TtNUS SOP GH-3.4; Ground-penetrating Radar Surveys

ATTACHMENT 1
LISTING OF UNDERGROUND UTILITY CLEARANCE RESOURCES

American Public Works Association
2345 Grand Boulevard, Suite 500, Kansas City, MO 64108-2625
Phone (816) 472-6100 • Fax (816) 472-1610
Web www.apwa.net • E-mail apwa@apwa.net

ONE-CALL SYSTEMS INTERNATIONAL CONDENSED DIRECTORY

Alabama
Alabama One-Call
1-800-292-8525

Alaska
Locate Call Center of Alaska, Inc.
1-800-478-3121

Arizona
Arizona Blue Stake
1-800-782-5348

Arkansas
Arkansas One Call System, Inc.
1-800-482-8998

California
Underground Service Alert North
1-800-227-2600
Underground Service Alert of Southern California
1-800-227-2600

Colorado
Utility Notification Center of Colorado
1-800-922-1987

Connecticut
Call Before You Dig
1-800-922-4455

Delaware
Miss Utility of Delmarva
1-800-282-8555

Florida
Sunshine State One-Call of Florida, Inc.
1-800-432-4770

Georgia
Underground Protection Center, Inc.
1-800-282-7411

Hawaii
Underground Service Alert North
1-800-227-2600

Idaho
Dig Line Inc.
1-800-342-1585
Kootenai County One-Call
1-800-428-4950
Shoshone - Benewah One-Call
1-800-398-3285

Illinois
JULIE, Inc.
1-800-892-0123
Digger (Chicago Utility Alert Network)
312-744-7000

Indiana
Indiana Underground Plant Protection Service
1-800-382-5544

Iowa
Iowa One-Call
1-800-292-8989

Kansas
Kansas One-Call System, Inc.
1-800-344-7233

Kentucky
Kentucky Underground Protection Inc.
1-800-752-6007

Louisiana
Louisiana One Call System, Inc.
1-800-272-3020

Maine
Dig Safe System, Inc.
1-888-344-7233

Maryland
Miss Utility
1-800-257-7777
Miss Utility of Delmarva
1-800-282-8555

Massachusetts
Dig Safe System, Inc.
1-888-344-7233

Michigan
Miss Dig System, Inc.
1-800-482-7171

Minnesota
Gopher State One Call
1-800-252-1166

Mississippi
Mississippi One-Call System, Inc
1-800-227-6477

Missouri
Missouri One-Call System, Inc.
1-800-344-7483

Montana
Utilities Underground Protection Center
1-800-424-5555
Montana One Call Center
1-800-551-8344

Nebraska
Diggers Hotline of Nebraska
1-800-331-5666

Nevada
Underground Service Alert North
1-800-227-2600

New Hampshire
Dig Safe System, Inc.
1-888-344-7233

New Jersey
New Jersey One Call
1-800-272-1000

New Mexico
New Mexico One Call System, Inc.
1-800-321-2537
Las Cruces- Dona Ana Blue Stakes
1-888-526-0400

New York
Dig Safely New York
1-800-962-7962
New York City- Long Island One Call Center
1-800-272-4480

North Carolina
The North Carolina One-Call Center, Inc.
1-800-632-4949

North Dakota
North Dakota One-Call
1-800-795-0555

Ohio
Ohio Utilities Protection Service
1-800-362-2764
Oil & Gas Producers Underground Protect'n Svc
1-800-925-0988

Oklahoma
Call Okie
1-800-522-6543

Oregon
Oregon Utility Notification Center/One Call Concepts
1-800-332-2344

Pennsylvania
Pennsylvania One Call System, Inc.
1-800-242-1776

Rhode Island
Dig Safe System, Inc.
1-888-344-7233

South Carolina
Palmetto Utility Protection Service Inc.
1-888-721-7877

South Dakota
South Dakota One Call
1-800-781-7474

Tennessee
Tennessee One-Call System, Inc.
1-800-351-1111

ATTACHMENT 1 (Continued)

Texas
Texas One Call System
1-800-245-4545
Texas Excavation Safety System, Inc.
1-800-344-8377
Lone Star Notification Center
1-800-669-8344

Utah
Blue Stakes of Utah
1-800-662-4111

Vermont
Dig Safe System, Inc.
1-888-344-7233

Virginia
Miss Utility of Virginia
1-800-552-7001
Miss Utility (Northern Virginia)
1-800-257-7777

Washington
Utilities Underground Location Center
1-800-424-5555
Northwest Utility Notification Center
1-800-553-4344
Inland Empire Utility Coordinating Council
509-456-8000

West Virginia
Miss Utility of West Virginia, Inc.
1-800-245-4848

Wisconsin
Diggers Hotline, Inc.
1-800-242-8511

Wyoming
Wyoming One-Call System, Inc.
1-800-348-1030
Call Before You Dig of Wyoming
1-800-849-2476

District of Columbia
Miss Utility
1-800-257-7777

Alberta
Alberta One-Call Corporation
1-800-242-3447

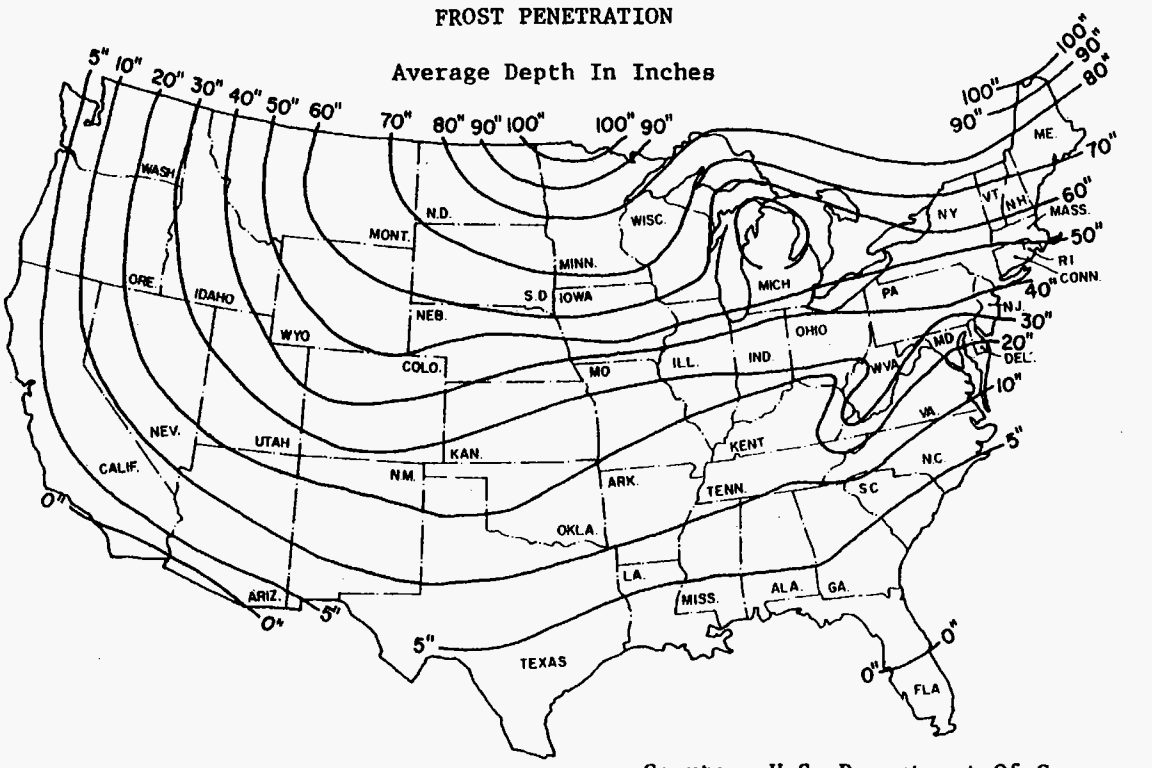
British Columbia
BC One Call
1-800-474-6886

Ontario
Ontario One-Call System
1-800-400-2255

Quebec
Info-Excavation
1-800-663-9228

ATTACHMENT 2

FROST LINE PENETRATION DEPTHS BY GEOGRAPHIC LOCATION



Courtesy U.S. Department Of Commerce

ATTACHMENT 3
UTILITY CLEARANCE FORM

Client: _____ Project Name: _____

Project No.: _____ Completed By: _____

Location Name: _____ Work Date: _____

Excavation Method/Overhead Equipment: _____

1. Underground Utilities — Circle One

a)	Review of existing maps?	yes	no	N/A
b)	Interview local personnel?	yes	no	N/A
c)	Site visit and inspection?	yes	no	N/A
d)	Excavation areas marked in the field?	yes	no	N/A
e)	Utilities located in the field?	yes	no	N/A
f)	Located utilities marked/added to site maps?	yes	no	N/A
g)	Client contact notified Name _____ Telephone: _____ Date: _____	yes	no	N/A
g)	State One-Call agency called? Caller: _____ Ticket Number: _____ Date: _____	yes	no	N/A
h)	Geophysical survey performed? Survey performed by: _____ Method: _____ Date: _____	yes	no	N/A
i)	Hand excavation performed (with concurrent use of utility detection device)? Completed by: _____ Total depth: _____ feet Date: _____	yes	no	N/A
j)	Trench/excavation probed? Probing completed by: _____ Depth/frequency: _____ Date: _____	yes	no	N/A

2. Overhead Utilities — Present Absent

a)	Determination of nominal voltage	yes	no	N/A
b)	Marked on site maps	yes	no	N/A
c)	Necessary to lockout/insulate/re-route	yes	no	N/A
d)	Document procedures used to lockout/insulate/re-route	yes	no	N/A
e)	Minimum acceptable clearance (SOP Section 5.2): _____			

3. Notes:

_____

_____

_____

Approval:

_____ _____

Site Manager/Field Operations Leader Date

c: PM/Project File
Program File

ATTACHMENT 4
OSHA LETTER OF INTERPRETATION

Mr. Joseph Caldwell
Consultant
Governmental Liaison
Pipeline Safety Regulations
211 Wilson Boulevard
Suite 700
Arlington, Virginia 22201

Re: Use of hydro-vacuum or non-conductive hand tools to locate underground utilities.

Dear Mr. Caldwell:

In a letter dated July 7, 2003, we responded to your inquiry of September 18, 2002, regarding the use of hydro-vacuum equipment to locate underground utilities by excavation. After our letter to you was posted on the OSHA website, we received numerous inquiries that make it apparent that aspects of our July 7 letter are being misunderstood. In addition, a number of industry stakeholders, including the National Utility Contractors Association (NUCA), have provided new information regarding equipment that is available for this work.

To clarify these issues, we are withdrawing our July 7 letter and issuing this replacement response to your inquiry.

Question: *Section 1926.651 contains several requirements that relate to the safety of employees engaged in excavation work. Specifically, paragraphs (b)(2) and (b)(3) relate in part to the safety of the means used to locate underground utility installations that, if damaged during an uncovering operation, could pose serious hazards to employees.*

Under these provisions, what constitutes an acceptable method of uncovering underground utility lines, and further, would the use of hydro-vacuum excavation be acceptable under the standard?

Answer

Background

Two sections of 29 CFR 1926 Subpart P (Excavations), 1926.651(Specific excavation requirements), govern methods for uncovering underground utility installations. Specifically, paragraph (b)(2) states:

> When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours * * * or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used. (emphasis added).

Paragraph (b)(3) provides:

ATTACHMENT 4 (Continued)

> When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means. (emphasis added).

Therefore, "acceptable means" must be used where the location of the underground utilities have not been identified by the utility companies and detection equipment is not used.

Subpart P does not contain a definition of either "other acceptable means" or "safe and acceptable means." The preambles to both the proposed rule and the final rule discussed the rationale behind the wording at issue. For example, the preamble to the proposed rule, 52 Fed. Reg. 12301 (April 15, 1987), noted that a 1972 version of this standard contained language that specified "careful probing or hand digging" as the means to uncover utilities. The preamble then noted that an amendment to the 1972 standard later deleted that language "to allow other, *equally effective means* of locating such installations." The preamble continued that in the 1987 proposed rule, OSHA again proposed using language in section (b)(3) that would provide another example of an acceptable method of uncovering utilities that could be used *where the utilities have not been marked and detection equipment is not being used* – "probing with hand-held tools." This method was rejected in the final version of 29 CFR 1926. As OSHA explained in the preamble to the final rule, 54 Fed. Reg. 45916 (October 31, 1989):

> OSHA received two comments * * * and input from ACCSH [OSHA's Advisory Committee on Construction Safety and Health] * * * on this provision. All commenters recommended dropping 'such as probing with hand-held tools' from the proposed provision, because this could create a hazard to employees by damaging the installation or its insulation.

In other words, the commenters objected to the use of hand tools being used unless detection equipment was used in conjunction with them. OSHA then concluded its discussion relative to this provision by agreeing with the commentators and ultimately not including any examples of "acceptable means" in the final provision.

Non-conductive hand tools are permitted

This raises the question of whether the standard permits the use of hand tools alone -- without also using detection equipment. NUCA and other industry stakeholders have recently informed us that non-conductive hand tools that are appropriate to be used to locate underground utilities are now commonly available.

Such tools, such as a "shooter" (which has a non-conductive handle and a snub nose) and non-conductive or insulated probes were not discussed in the rulemaking. Since they were not considered at that time, they were not part of the class of equipment that was thought to be unsafe for this purpose. Therefore, we conclude that the use of these types of hand tools, when used with appropriate caution, is an "acceptable means" for locating underground utilities.

ATTACHMENT 4 (Continued)

Hydro-vacuum excavation

It is our understanding that some hydro-vacuum excavation equipment can be adjusted to use a minimum amount of water and suction pressure. When appropriately adjusted so that the equipment will not damage underground utilities (especially utilities that are particularly vulnerable to damage, such as electrical lines), use of such equipment would be considered a "acceptable means" of locating underground utilities. However, if the equipment cannot be sufficiently adjusted, then this method would not be acceptable under the standard.

Other technologies

We are not suggesting that these are the only devices that would be "acceptable means" under the standard. Industry stakeholders have informed us that there are other types of special excavation equipment designed for safely locating utilities as well.

We apologize for any confusion our July 7 letter may have caused. If you have further concerns or questions, please feel free to contact us again by fax at: U.S. Department of Labor, OSHA, Directorate of Construction, Office of Construction Standards and Compliance Assistance, fax # 202-693-1689. You can also contact us by mail at the above office, Room N3468, 200 Constitution Avenue, N.W., Washington, D.C. 20210, although there will be a delay in our receiving correspondence by mail.

Sincerely,

Russell B. Swanson, Director
Directorate of Construction

NOTE: OSHA requirements are set by statute, standards and regulations. Our interpretation letters explain these requirements and how they apply to particular circumstances, but they cannot create additional employer obligations. This letter constitutes OSHA=s interpretation of the requirements discussed. Note that our enforcement guidance may be affected by changes to OSHA rules. Also, from time to time we update our guidance in response to new information. To keep apprised of such developments, you can consult OSHA's website at http://www.osha.gov.

Field Forms

Tetra Tech NUS, Inc.

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

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

TETRA TECH

MRP FF.1

SAP Worksheet #4 (Field Personnel)

Project Personnel Sign-off Sheet

Facility/Location: _____

Site(s): _____

Date	Organization/Role	Name	Signature
	Tetra Tech/SUXOS		
	Tetra Tech/UXOQCS		
	Tetra Tech/UXOSO (if different than UXOQCS)		
	Tetra Tech/Technician		
	Tetra Tech/ Technician		
	Tetra Tech/ Technician		
	Tetra Tech/ Technician		
	Tetra Tech/ Technician		
	Tetra Tech/ Technician		
	Tetra Tech/ Technician		
	Tetra Tech/ Technician		
	Site Geophysicist		
	Staff Geophysicist		
	Staff Geophysicist		
	Staff Geophysicist		

I have read and understood the SAP relative to assigned roles, per SAP Worksheet No. 3.

TETRA TECH

MRP FF.2

DAILY MEC ACTIVITY LOG

Facility/Location: _____

Site(s): _____

FIELD ACTIVITY SUBJECT:	**Date:**
PROJECT NO:	**TASK CODES**:

SUMMARY OF DAILY PROGRESS: (Update Definable Feature of Work - Worksheet 12)

Mobilization/Set Preparation:

Site Survey:

Vegetation Management:

GPS Positional Data:

Detector Aided Surface Surveys:

Target Reacquisition:

Intrusive Operation:

Donor Explosives Handling/Storage:

MEC Management (Treatment):

MPPEH Management (Inspections):

MPPEH Management (Certification):

MPPEH Management (Disposal):

Demobilization:

Other:

LIST OF MEC ITEMS ID, MPPEH ITEM ID, MDAS, OR NONE
(for documentation see MEC/MPPEH/MDAS Tracking Logs for added details)**:**

Item ID	Description	Item ID	Description

TETRA TECH

MRP FF.2

DAILY MEC ACTIVITY LOG

Facility/Location: _____

Site(s): _____

FIELD ACTIVITY SUBJECT:	**Date:**
DESCRIPTION OF DAILY ACTIVITIES AND EVENTS:	
IMPORTANT PHONE CALLS/DECISIONS:	
FIELD TASK MODIFICATIONS:	
WEATHER CONDITIONS:	
VISITORS ON SITE:	
PERSONNEL ON SITE:	
SIGNATURE:	**DATE:**

TETRA TECH

MRP FF.3
DAILY EQUIPMENT CHECKLIST

Facility/Location: _____

Site(s): _____

Equipment:					**Initial Condition Out of the Box Acceptable (Y/N/NA)**				
Serial Number:					**Inspection**		**Spare parts**		**Cable Shake Test**
Description:									
Date Out	**Time Out**	**Daily Cond. & Comments Out**	**Monument Check (1)**	**Checked Out By**	**Date In**	**Time In**	**Daily Cond. & Comments In**	**Checked In By**	**Monument Check (1)**

(1) For GPS Units, confirm accuracy correlation to referenced monument locations. Please record general description of monument locations in the Daily Activity Log, once established. (Example – GPS QC Location – Well MW-3 or northwest corner of intersection of Perimeter Road and Munitions Street)

Last Revised: 3/31/2011

TETRA TECH

MRP FF.4
VISITOR'S LOG

Facility/Location: _____

Site(s): _____

DATE	Time		PRINT NAME	SIGNATURE	ORGANIZATION	PHONE #	RAC
	In	Out					

Last Revised: 3/31/2011

TETRA TECH

MRP FF.5
Photographic Log

Facility/Location: _____

Site(s): _____

Photograph Number	Date	Taken By (initials)	Subject/Description	Anomaly ID (if applicable)	Remarks/Comments

Last Revised: 3/31/2011

TETRA TECH

MRP FF.5
Photographic Log

Facility/Location: _____

Site(s): _____

Photograph Number	Date	Taken By (initials)	Subject/Description	Anomaly ID (if applicable)	Remarks/Comments

Last Revised: 3/31/2011

TETRA TECH

MRP FF.5
Photographic Log

Facility/Location: _____

Site(s): _____

Photograph Number	Date	Taken By (initials)	Subject/Description	Anomaly ID (if applicable)	Remarks/Comments

Last Revised: 3/31/2011

TETRA TECH

MRP FF.5
Photographic Log

Facility/Location: _____

Site(s): _____

Photograph Number	Date	Taken By (initials)	Subject/Description	Anomaly ID (if applicable)	Remarks/Comments

TETRA TECH
MRP FF.8
MEC/MPPEH LOG FOR UXO AVOIDANCE ACTIVITIES

Facility/Location: _____

Site(s): _____

ID #	Item	Date Identified	GPS Location* US Survey Feet		Physical Condition/ Appearance	Classification (MEC/MPPEH)	Resolution (EOD Called, Left in Place, etc)	Resolution/ Disposition Date
			Northing (feet)	Easting (feet)				

* GPS data were collected using the North American Datum of 1983, _____ (US Survey Feet). See Figure _____ for item locations.

Last Revised: 3/31/2010

Facility/Location: _____

Site(s): _____

MEC DATA AND ACCOUNTABILITY FORM

FOR UXO TEAM USE

Assigned ID No.: | Team Leader:

Grid or Lane Number: | Work Area: | Date:

Location: X (Lat): _____ Y (Long): _____ Location Type (UW or UG): _____

Other Location Information: _____

Depth (feet): _____ Inclination (Degrees): _____ Orientation (N–S, E-W): _____

TARGET/ANOMALY CHARACTERISTICS

Type of Target/Find: ☐ Surface Find ☐ Mag & Dig Target ☐ Primary Geo Target ☐ Validation (QA/QC) ☐ No Dig

Type of Anomaly: ☐ UXO ☐ MEC ☐ Inert ☐ Practice ☐ MC (waste) ☐ MD (scrap) ☐ Metal Waste ☐ No Find ☐ Rock ☐ Rust Layer ☐ Oxidation ☐ Misc.: _____

Diameter/Width: | Length: | Estimated Weight:

DIGITAL PHOTO RECORD

Was photo taken? ☐ Yes ☐ No | Camera No.: | Frame No.: | File Name:

MUNITIONS NOMENCLATURE (If Known, Record Below and record fuze condition and disposition)

Munitions Mark/Mod: | Fuze Mark/Mod: ☐ Nose: _____ ☐ Tail: _____ ☐ Transverse: _____ ☐ Casing: _____ | N.E.W. Total:

MUNITIONS CHARACTERISTICS

Munitions Filler: ☐ Explosive ☐ Inert ☐ Propellant ☐ Pyrotechnic ☐ Unknown ☐ Other: _____

Munitions Category: ☐ Depth Charges ☐ Land Mine ☐ Projectiles ☐ Sea Mines ☐ Fuze ☐ Bombs ☐ Grenades ☐ Misc. Explosive Devices ☐ Pyrotechnics and Flares ☐ Small Arms ☐ Clusters/Dispensers ☐ Guided Missiles ☐ Mortars ☐ Rockets ☐ Torpedoes

FUZE CHARACTERISTICS

Fuze Location(s) (check all that apply): ☐ Nose ☐ Tail ☐ Transverse ☐ Casing | Breaks in Fuze Body? ☐ Yes ☐ No | Fuze Markings:

Fuzing Type(s): ☐ Hydrostatic ☐ MT Long Delay ☐ Powder Train Time Fuze ☐ Nose MT/Tail Impact Inertia ☐ All-ways Acting ☐ Impact ☐ MT Superquick ☐ Pressure ☐ Pt-initiating-Base-detonating ☐ Base Detonating ☐ Influence ☐ Piezo-Electric ☐ Proximity (VT) ☐ Electric ☐ Mech Time (MT) ☐ Point Detonating (PD) ☐ Nose MT/Tail Pressure

Fuze Length: | Fuze Diameter: | Diameter of Fuze Well:

MEC STATUS & PHYSICAL CONDITION (Check all that apply)

☐ Armed ☐ Unarmed ☐ Fired ☐ Unfired ☐ Intact ☐ Broken Open ☐ Filler Visible ☐ Soil Staining

FOR SUXOS USE

Disposition: (Clarify Under Remarks) (GPS all disposition location if not BIP) ☐ Transferred ☐ Transported ☐ Left In Place ☐ Destroyed ☐ BIP ☐ Other : _____ | Date:

Client Notifications By: | Signature: | Date

Transferred To: | Signature: | Date:

Destroyed By: | Signature | Date:

Remarks: (indicate if item completely destroyed or rendered MDAS and disposed of in an MSDA Container, list container number)

SUXOS Signature: | Date:

TETRA TECH
MRP FF.14.1
DAILY DGM QUALITY CONTROL REPORT

Facility/Location: _____

Site(s): _____

Project Number:	Date:
Personnel Present:	
List Features of Work and Equipment Used, Locations (areas surveyed)	
Rework Items Identified Today (Not Corrected by Close of Business)	Rework Items Corrected Today
Remarks/Describe any Idle or Downtime and/or Equipment Problems	
On behalf of the contractor, I certify that this report is complete and correct and the equipment and material used and work performed during this reporting period is in compliance with the contract drawings and specifications to the best of my knowledge except as noted in this report.	_____ ERT Representative Date
Tetra Tech Quality Assurance	
Quality Assurance Representative Remarks and/or Exceptions to the Report	
Inspection of Field Activities Performed	_____ Tetra Tech QA Representative Date

TETRA TECH
MRP FF.14.2
DGM INSTRUMENT VERIFICATION STRIP (IVS) INSTALLATION CHECKLIST

Facility/Location: _____

Site(s): _____

Project No:	**Date**:

I. Test Plot Information

Have survey objectives been determined, clarified, and documented?	Y	N	NA
Will the IVS be available during the project for the evaluation of suspected instrument malfunctions or evaluation of new equipment and operators?	Y	N	NA
Has surface clearance been performed?	Y	N	NA
Has background geophysical survey been performed before burial?	Y	N	NA
Measure depth to top and center of mass of each object?	Y	N	NA

Item No.	Inert Item/Surrogate Description	Depth (inches)	Azimuth/ Inclination Angle (Degrees)	GPSed (Y/N0	Expected Response Range (DGM)	Comment
1						
2						
3						
4						
5						
6						
7						

II. Instrument Information

Instrument Type/Manufacture	Instrument Serial Number	Measured Response (DGM)	Test Results - Initials of personnel Testing Equipment ☒ indicates good for operation				Comments (pass/fail) Explain below
			AM	AM	PM	PM	
			☐		☐		
			☐		☐		
			☐		☐		
			☐		☐		
			☐		☐		
			☐		☐		
			☐		☐		

III. Problems Encountered / Corrective Actions Taken.

explain in space below:

IV. Supervisor

Name and Signature:	**Title/Company**:	**Date**:

TETRA TECH
MRP FF.14.3
DGM DAILY IVS CHECKLIST

Facility/Location: _____

Site(s): _____

Project No:	**Date**:

I. Test Plot Information

Location: (See IVS Installation Checklist)

Item No.	Inert Item/Surrogate Description	Depth (inches)	Expected Response Range (DGM)	Comments
1				
2				
3				
4				
5				
6				
7				

II. Instrument Information

Instrument Type/ Manufacture	Instrument Serial Number	Measured Response (DGM)	GPS Monuments	Test Results,- Personnel Testing Equipment ☒ indicates good for operation				Comments
				AM	AM	PM	PM	
				☐		☐		
				☐		☐		
				☐		☐		
				☐		☐		
				☐		☐		
				☐		☐		
				☐		☐		
				☐		☐		
				☐		☐		
				☐		☐		

III. Problems Encountered / Corrective Actions Taken.

explain in space below:

IV. Supervisor

Name and Signature:	**Title/Company**:	**Date**:

TETRA TECH
MRP FF.14.4
DGM INITIAL INSTRUMENT CHECKLIST

Facility/Location: _____

Site(s): _____

Name and Title: _____
Date: _____

Has the sensor travel test been performed (for underwater surveys), and are the results acceptable to meet survey objectives?	Y	N	NA
Has the GPS unit been checked for accuracy requirements against two known locations?	Y	N	NA
Has the optimum sensor height for each instrument been determined?	Y	N	NA
Have the pull-away and/or interferences tests been performed and successfully demonstrated no influence for navigational or towing equipment?	Y	N	NA
Has an appropriate data acquisition rate been selected?	Y	N	NA

TETRA TECH
MRP FF.14.5
DGM DAILY INSTRUMENT CHECKLIST

Facility/Location: _____

Site(s): _____

Name and Title: _____
Date: _____

Has the operator been checked for presence of metal?	Y	N	NA
Has the instrument been warmed-up?	Y	N	NA
Have the sensor positions been measured and recorded?	Y	N	NA
Has a static background and spike test been performed successfully?	Y	N	NA
Has the equipment function test been performed with detection of all the test targets?	Y	N	NA
Have all loose cables been secured?	Y	N	NA
Has the EM61 or EM31 been nulled (power on)?			
Has the geophysical equipment been set up according to manufacturer's specifications?	Y	N	NA
Were the data monitored during data collection for anything unusual?	Y	N	NA

TETRA TECH
MRP FF.14.6
DGM FIELD EDITING CHECKLIST

Facility/Location: _____

Site(s): _____

Name and Title: _____
Date: _____

Have the following items been evaluated for correctness and edited if necessary:

Line numbers?	Y	N	NA
Start and end points?	Y	N	NA
Line direction?	Y	N	NA
Fiducial locations?	Y	N	NA

Have the data been examined for geophysical noise?	Y	N	NA
Have the data been examined for the presence of drop-outs and spikes?	Y	N	NA
Have the edited data been converted to the appropriate .xyz format?	Y	N	NA

If using magnetics, have the following steps been taken:

Examined base station data for any problems?	Y	N	NA
Performed diurnal correction to field magnetometer data?	Y	N	NA

Have the positional data been evaluated for accuracy and completeness?	Y	N	NA

TETRA TECH
MRP FF.23
FIELD CHANGE REQUEST (FCR)

Facility/Location: _____

Site(s): _____

CONTRACT TASK ORDER NAME:	**CTO #**	**CHANGE REQUEST NO.**
TO:	**LOCATION:**	**DATE:**

RE:

SAP Worksheet: _____ Section: _____

ESS Section: _____

SOP Section: _____

Other: _____

1. DESCRIPTION (cite or attach specific text/figure changes, as necessary):

2. REASON FOR CHANGE

3. RECOMMENDED DISPOSITION (Submit sketch, if applicable):

_____ Minor Change _____ Major Change (Impacts Cost, Schedule)

4. APPROVAL:

_____ Not Approved (give reason).

_____ Considered minor change – APPROVED per recommended disposition – Documents will not be formally revised.

_____ Considered major change – Client approval required via contract modification process

Prepared by (Signature)	**Date:**
Tetra Tech UXO Manager (Signature)	**Date:**
Tetra Tech Project Manager (Signature)	**Date:**
Client Point of Contact / Client Representative (Signature) (Not applicable if minor change)	**Date:**

TETRA TECH

MRP FF.24
EQUIPMENT MAINTENANCE/REPAIR

Facility/Location: _____

Site(s): _____

MAINTENANCE/REPAIR NO._____

NECESSARY ATTACHMENTS _____ PACKING SLIP, and/or _____ MRR, abd _____LOGS

TYPE OF EQUIPMENT	SERIAL NO.
MAKE:	MODEL:
P O NUMBER	DELIVERY ORDER NO.
STANDARD MAINTENANCE	DATE

DESCRIPTION OF PROBLEM (if any)

_____

_____

_____

MAINTENANCE/REPAIRS TO BE PERFORMED

IN-HOUSE REPAIRS	DATE
SENT OUT TO	COST ESTIMATE AIRBILL NO. P O NO. DATE RET'D

CORRECTIVE ACTION

_____

_____

_____

_____

PARTS LIST

PART DESCRIPTION	QUANTITY	COST/EA

TOTAL LABOR (hours) PERFORMED BY	DATE

RETURNED TO WHICH JOB SITE/Stone Mountain, GA

Last Revised: 3/31/2011

APPENDIX B

PROJECT SCREENING LEVEL BACKUP TABLES

HUMAN HEALTH SOIL SCREENING VALUES

Chemical	CAS #	EPA Residential Soil Direct Contact (mg/kg)	Basis	Adjusted EPA Residential Soil Direct Contact (mg/kg)	PAL Reference
TAL Metals					
ALUMINUM	7429-90-5	77000	n	7700	EPA RSL
ANTIMONY	7440-36-0	31	n	3.1	EPA RSL
ARSENIC	7440-38-2	0.39	c	0.39	EPA RSL
BARIUM	7440-39-3	15000	n	1500	EPA RSL
BERYLLIUM	7440-41-7	160	n	16	EPA RSL
CADMIUM	7440-43-9	70	n	7	EPA RSL
CALCIUM	7440-70-2	NC	--	NC	EPA RSL
CHROMIUM(1)	7440-47-3	0.29	c	0.29	EPA RSL
COBALT	7440-48-4	23	n	2.3	EPA RSL
COPPER	7440-50-8	3100	n	310	EPA RSL
IRON	7439-89-6	55000	n	5500	EPA RSL
LEAD	7439-92-1	400		400	EPA RSL
MERCURY	7439-97-6	10	n	1	EPA RSL
MAGNESIUM	7439-95-4	NC	--	NC	EPA RSL
MANGANESE	7439-96-5	1800	n	180	EPA RSL
NICKEL	7440-02-0	1500	n	150	EPA RSL
POTASSIUM	7440-09-7	NC	--	NC	EPA RSL
SELENIUM	7782-49-2	390	n	39	EPA RSL
SILVER	7440-22-4	390	n	39	EPA RSL
SODIUM	7440-23-5	NC	--	NC	EPA RSL
THALLIUM	7440-28-0	0.78	n	0.078	EPA RSL
VANADIUM(2)	7440-62-2	390	n	39	EPA RSL
ZINC	7440-66-6	23000	n	2300	EPA RSL
TCL VOCs					
1,1- DICHLOROETHANE	75-34-3	3.3	c	3.3	EPA RSL
1,1,1-TRICHLOROETHANE	71-55-6	8700	n	870	EPA RSL
1,1,2- TRICHLOROETHANE	79-00-5	1.6	n	0.16	EPA RSL
1,1,2,2- TETRACHLORETHANE	79-34-5	0.56	c	0.56	EPA RSL
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	76-13-1	43000	n	4300	EPA RSL
1,1-DICHLOROETHENE	75-35-4	240	n	24	EPA RSL
1,2- DICHLOROBENZENE	95-50-1	1900	n	190	EPA RSL
1,2- DICHLOROETHANE	107-06-2	0.43	c	0.43	EPA RSL
1,2,3-TRICHLOROBENZENE	87-61-6	49	n	4.9	EPA RSL
1,2,4-TRICHLOROBENZENE	120-82-1	62	n	6.2	EPA RSL
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	0.0054	c	0.0054	EPA RSL
1,2-DIBROMOETHANE	106-93-4	0.034	c	0.034	EPA RSL
1,2-DICHLOROPROPANE	78-87-5	0.94	c	0.94	EPA RSL
1,3-DICHLOROBENZENE	541-73-1	NC	c	NC	EPA RSL
1,4- DICHLOROBENZENE	106-46-7	2.4	c	2.4	EPA RSL
1,4-DIOXANE	123-91-1	4.9	c	4.9	EPA RSL
2-BUTANONE	78-93-3	28000	n	2800	EPA RSL
2-HEXANONE	591-78-6	210	n	21	EPA RSL
4-METHYL-2-PENTANONE	108-10-1	5300	n	530	EPA RSL
ACETONE	67-64-1	61000	n	6100	EPA RSL
BENZENE	71-43-2	1.1	c	1.1	EPA RSL
BROMOCHLOROMETHANE	74-97-5	160	n	16	EPA RSL
BROMODICHLOROMETHANE	75-27-4	0.27	c	0.27	EPA RSL
BROMOFORM	75-25-2	62	c	62	EPA RSL
BROMOMETHANE	74-83-9	7.3	n	0.73	EPA RSL
CARBON DISULFIDE	75-15-0	820	n	82	EPA RSL
CARBON TETRACHLORIDE	56-23-5	0.61	c	0.61	EPA RSL
CHLOROBENZENE	108-90-7	290	n	29	EPA RSL
CHLOROETHANE	75-00-3	15000	n	1500	EPA RSL
CHLOROFORM	67-66-3	0.29	c	0.29	EPA RSL
CHLOROMETHANE	74-87-3	120	n	12	EPA RSL
CIS-1,2- DICHLOROETHENE	156-59-2	160	n	16	EPA RSL
CIS-1,3- DICHLOROPROPENE(3)	10061-01-5	1.7	c	1.7	EPA RSL
CYCLOHEXANE	110-82-7	7000	n	700	EPA RSL
DIBROMOCHLOROMETHANE	124-48-1	0.68	c	0.68	EPA RSL
DICHLORODIFLUOROMETHANE	75-71-8	94	n	9.4	EPA RSL
ETHYLBENZENE	100-41-4	5.4	c	5.4	EPA RSL
ISOPROPYLBENZENE	98-82-8	2100	n	210	EPA RSL
METHYL ACETATE	79-20-9	78000	n	7800	EPA RSL
METHYL TERT-BUTYL ETHER	1634-04-4	43	c	43	EPA RSL
METHYLCYCLOHEXANE	108-87-2	NC	--	NC	EPA RSL
METHYLENE CHLORIDE	75-09-2	360	n	36	EPA RSL
STYRENE	100-42-5	6300	n	630	EPA RSL
TETRACHLOROETHENE	127-18-4	86	n	8.6	EPA RSL
TOLUENE	108-88-3	5000	n	500	EPA RSL
O-XYLENE	95-47-6	690	n	69	EPA RSL
m,p-XYLENE	108-38-3	590	n	59	EPA RSL
TOTAL XYLENES	1330-20-7	630	n	63	EPA RSL
TRANS-1,2- DICHLOROETHENE	156-60-5	150	n	15	EPA RSL
TRANS-1,3-DICHLOROPROPENE(3)	10061-02-6	1.7	c	1.7	EPA RSL
TRICHLOROETHENE	79-01-6	4.4	n	0.44	EPA RSL
TRICHLOROFLUOROMETHANE	75-69-4	790	n	79	EPA RSL
VINYL CHLORIDE	75-01-4	0.06	c	0.06	EPA RSL

HUMAN HEALTH SOIL SCREENING VALUES

Chemical	CAS #	EPA Residential Soil Direct Contact (mg/kg)	Basis	Adjusted EPA Residential Soil Direct Contact (mg/kg)	PAL Reference
TCL SVOCs					
1,1'-BIPHENYL	92-52-4	51	n	5.1	EPA RSL
1,2,4,5-TETRACHLOROBENZENE	95-94-3	18	n	1.8	EPA RSL
2,2-OXYBIS(1-CHLOROPROPANE)	108-60-1	4.6	c	4.6	EPA RSL
2,3,4,6-TETRACHLOROPHENOL	58-90-2	1800	n	180	EPA RSL
2,4,5-TRICHLOROPHENOL	95-95-4	6100	n	610	EPA RSL
2,4,6-TRICHLOROPHENOL	88-06-2	61	n	6.1	EPA RSL
2,4-DICHLOROPHENOL	120-83-2	180	n	18	EPA RSL
2,4-DIMETHYLPHENOL	105-67-9	1200	n	120	EPA RSL
2,4-DINITROPHENOL	51-28-5	120	n	12	EPA RSL
2,4-DINITROTOLUENE	121-14-2	1.6	c	1.6	EPA RSL
2,6-DINITROTOLUENE	606-20-2	61	n	6.1	EPA RSL
2-CHLORONAPHTHALENE	91-58-7	6300	n	630	EPA RSL
2-CHLOROPHENOL	95-57-8	390	n	39	EPA RSL
2-METHYLNAPHTHALENE	91-57-6	230	n	23	EPA RSL
2-METHYLPHENOL	95-48-7	3100	n	310	EPA RSL
2-NITROANILINE	88-74-4	610	n	61	EPA RSL
2-NITROPHENOL	88-75-5	NC	--	NC	EPA RSL
3,3'-DICHLOROBENZIDINE	91-94-1	1.1	c	1.1	EPA RSL
3-NITROANILINE[(4)]	99-09-2	24	c	24	EPA RSL
4,6-DINITRO-2-METHYLPHENOL	534-52-1	4.9	n	0.49	EPA RSL
4-BROMOPHENYL-PHENYLETHER	101-55-3	NC	--	NC	EPA RSL
4-CHLORO-3-METHYLPHENOL	59-50-7	6100	n	610	EPA RSL
4-CHLOROANILINE	106-47-8	2.4	c	2.4	EPA RSL
4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	NC	--	NC	EPA RSL
4-METHYLPHENOL	106-44-5	6100	n	610	EPA RSL
4-NITROANILINE	100-01-6	24	c	24	EPA RSL
4-NITROPHENOL	100-02-7	NC	--	NC	EPA RSL
ACENAPHTHENE	83-32-9	3400	n	340	EPA RSL
ACENAPHTHYLENE[(5)]	208-96-8	3400	n	340	EPA RSL
ANTHRACENE	120-12-7	17000	n	1700	EPA RSL
ATRAZINE	1912-24-9	2.1	c	2.1	EPA RSL
BENZALDEHYDE	100-52-7	7800	n	780	EPA RSL
BENZO(A)ANTHRACENE	56-55-3	0.15	c	0.15	EPA RSL
BENZO(A)PYRENE	50-32-8	0.015	c	0.015	EPA RSL
BENZO(B)FLUOROANTHENE	205-99-2	0.15	c	0.15	EPA RSL
BENZO(G,H,I)PERYLENE[(6)]	191-24-2	1700	n	170	EPA RSL
BENZO(K)FLUOROANTHENE	207-08-9	1.5	c	1.5	EPA RSL
BIS(2-CHLOROETHOXY) METHANE	111-91-1	180	n	18	EPA RSL
BIS-(2-CHLOROETHYL) ETHER	111-44-4	0.21	c	0.21	EPA RSL
BIS(2-ETHYLHEXYL) PHTHALATE	117-81-7	35	c	35	EPA RSL
BUTYLBENZYLPHTHALATE	85-68-7	260	c	260	EPA RSL
CAPROLACTAM	105-60-2	31000	n	3100	EPA RSL
CARBAZOLE	86-74-8	NC	--	NC	EPA RSL
CHRYSENE	218-01-9	15	c	15	EPA RSL
DIBENZO(A,H)ANTHRACENE	53-70-3	0.015	c	0.015	EPA RSL
DIBENZOFURAN	132-64-9	78	n	7.8	EPA RSL
DIETHYLPHTHALATE	84-66-2	49000	n	4900	EPA RSL
DIMETHYLPHTHALATE	131-11-3	NC	--	NC	EPA RSL
DI-N-BUTYLPHTHALATE	84-74-2	6100	n	610	EPA RSL
DI-N-OCTYLPHTHALATE	117-84-0	NC	--	NC	EPA RSL
FLUORANTHENE	206-44-0	2300	n	230	EPA RSL
FLUORENE	86-73-7	2300	n	230	EPA RSL
HEXACHLOROBENZENE	118-74-1	0.3	c	0.3	EPA RSL
HEXACHLOROBUTADIENE	87-68-3	61	n	6.1	EPA RSL
HEXACHLOROCYCLOPENTADIENE	77-47-4	370	n	37	EPA RSL
HEXACHLOROETHANE	67-72-1	43	n	4.3	EPA RSL
INDENO (1,2,3-CD)-PYRENE	193-39-5	0.15	c	0.15	EPA RSL
ISOPHORONE	78-59-1	510	c	510	EPA RSL
NAPHTHALENE	91-20-3	3.6	c	3.6	EPA RSL
NITROBENZENE	98-95-3	4.8	c	4.8	EPA RSL
N-NITROSO DIPHENYLAMINE	86-30-6	99	c	99	EPA RSL
N-NITROSO-DI-N PROPYLAMINE	621-64-7	0.069	c	0.069	EPA RSL
PENTACHLOROPHENOL	87-86-5	0.89	c	0.89	EPA RSL
PHENANTHRENE[(6)]	85-01-8	1700	n	170	EPA RSL
PHENOL	108-95-2	18000	n	1800	EPA RSL
PYRENE	129-00-0	1700	n	170	EPA RSL
TCL Pesticides					
4,4'-DDD	72-54-8	2	c	2	EPA RSL
4,4'-DDE	72-55-9	1.4	c	1.4	EPA RSL
4,4'-DDT	50-29-3	1.7	c	1.7	EPA RSL
ALDRIN	309-00-2	0.029	c	0.029	EPA RSL
ALPHA-BHC	319-84-6	0.077	c	0.077	EPA RSL
ALPHA-CHLORDANE[(7)]	5103-71-9	1.6	c	1.6	EPA RSL
BETA-BHC	319-85-7	0.27	c	0.27	EPA RSL
DELTA-BHC	319-86-8	NC	--	NC	EPA RSL
DIELDRIN	60-57-1	0.03	c	0.03	EPA RSL

HUMAN HEALTH SOIL SCREENING VALUES

Chemical	CAS #	EPA Residential Soil Direct Contact (mg/kg)	Basis	Adjusted EPA Residential Soil Direct Contact (mg/kg)	PAL Reference
ENDOSULFAN I[8]	959-98-8	370	n	37	EPA RSL
ENDOSULFAN II[8]	33213-65-9	370	n	37	EPA RSL
ENDOSULFAN SULFATE[8]	1031-07-8	370	n	37	EPA RSL
ENDRIN	72-20-8	18	n	1.8	EPA RSL
ENDRIN ALDEHYDE[9]	7421-93-4	18	n	1.8	EPA RSL
ENDRIN KETONE[9]	53494-70-5	18	n	1.8	EPA RSL
GAMMA-BHC (LINDANE)	58-89-9	0.52	c	0.52	EPA RSL
GAMMA-CHLORDANE[7]	5103-74-2	1.6	c	1.6	EPA RSL
HEPTACHLOR	76-44-8	0.11	c	0.11	EPA RSL
HEPTACHLOR EPOXIDE	1024-57-3	0.053	c	0.053	EPA RSL
METHOXYCHLOR	72-43-5	310	n	31	EPA RSL
TOXAPHENE	8001-35-2	0.44	c	0.44	EPA RSL
TCL PCBs					
AROCLOR-1016	12674-11-2	3.9	n	0.39	EPA RSL
AROCLOR-1221	11104-28-2	0.14	c	0.14	EPA RSL
AROCLOR-1232	11141-16-5	0.14	c	0.14	EPA RSL
AROCLOR-1242	53469-21-9	0.22	c	0.22	EPA RSL
AROCLOR-1248	12672-29-6	0.22	c	0.22	EPA RSL
AROCLOR-1254	11097-69-1	1.1	n	0.11	EPA RSL
AROCLOR-1260	11096-82-5	0.22	c	0.22	EPA RSL
AROCLOR-1262	37324-23-5	NC	--	NC	EPA RSL
AROCLOR-1268	11100-14-4	NC	--	NC	EPA RSL
EXPLOSIVES					
1,3,5-Trinitrobenzene	99-35-4	2200	n	220	EPA RSL
1,3-Dinitrobenzene	99-65-0	6.1	n	0.61	EPA RSL
2,4-Dinitrotoluene	121-14-2	1.6	c	1.6	EPA RSL
2,6-Dinitrotoluene	606-20-2	61	n	6.1	EPA RSL
Nitrobenzene	98-95-3	4.8	c	4.8	EPA RSL
2,4,6-Trinitrotoluene	118-96-7	36	n	3.6	EPA RSL
2-Amino-4,6-Dinitrotoluene	35572-78-2	150	n	15	EPA RSL
2-Nitrotoluene	88-72-2	2.9	c	2.9	EPA RSL
3-Nitrotoluene	99-08-1	6.1	n	0.61	EPA RSL
3,5-Dinitroaniline	618-87-1	NC	--	NC	EPA RSL
4-Amino-2,6-Dinitrotoluene	19406-51-0	150	n	15	EPA RSL
4-Nitrotoluene	99-99-0	240	n	24	EPA RSL
HMX	2691-41-0	3800	n	380	EPA RSL
Tetryl	479-45-8	240	n	24	EPA RSL
RDX	121-82-4	5.6	c	5.6	EPA RSL
PETN	78-11-5	120	n	12	EPA RSL
Nitroglycerin	55-63-0	6.1	n	0.61	EPA RSL

The USEPA RSL (May, 2012) residential soil screening level for noncarcinogens adjusted by dividing by 10, equivalent to a HQ of 0.1. The residential soil and industrial soil screening level for carcinogens (not adjusted) is equivalent to an ILCR of 1E-6.

Footnotes:
1) The value for hexavalent chromium is presented.
2) The value presented is for vanadium and compounds.
3) The value for 1,3-dichloropropene is presented.
4) The value for 4-nitroaniline is presented.
5) The value for acenaphthene is presented.
6) The value for pyrene is presented.
7) The value for chlordane is presented.
8) The value for endosulfan is presented.
9) The value for endrin is presented.

Acronyms:
c- carcinogenic
CAS - Chemical Abstract Service
EPA - United States Environmental Protection Agency
mg/kg - milligrams per kilogram
n - noncarcinogenic
NC - No Criteria
PAL - Project Action Limit
PCB - Polychlorinated Biphenyl
RSL - Regional Screening Level
SVOC - Semi-Volatile Organic Compound
TAL - Target Analyte List
TCL - Target Compound List
VOC - Volatile Organic Compound

HUMAN HEALTH GROUNDWATER SCREENING VALUES

Chemical	CAS #	EPA Tapwater (ug/L)	Basis	Adjusted EPA Tapwater RSL (ug/L)	PAL Reference
TAL Metals					
ALUMINUM	7429-90-5	16000	n	1600	Tapwater RSL
ANTIMONY	7440-36-0	6	n	0.6	Tapwater RSL
ARSENIC	7440-38-2	0.045	c	0.045	Tapwater RSL
BARIUM	7440-39-3	2900	n	290	Tapwater RSL
BERYLLIUM	7440-41-7	16	n	1.6	Tapwater RSL
CADMIUM	7440-43-9	6.9	n	0.69	Tapwater RSL
CALCIUM	7440-70-2	NC	--	NC	None
CHROMIUM(1)	7440-47-3	0.031	c	0.031	Tapwater RSL
COBALT	7440-48-4	4.7	n	0.47	Tapwater RSL
COPPER	7440-50-8	620	n	62	Tapwater RSL
IRON	7439-89-6	11000	n	1100	Tapwater RSL
LEAD	7439-92-1	15	n	15	MCL
MERCURY	7439-97-6	0.63	n	0.063	Tapwater RSL
MAGNESIUM	7439-95-4	NC	--	NC	None
MANGANESE	7439-96-5	320	n	32	Tapwater RSL
NICKEL	7440-02-0	300	n	30	Tapwater RSL
POTASSIUM	7440-09-7	NC	--	NC	None
SELENIUM	7782-49-2	78	n	7.8	Tapwater RSL
SILVER	7440-22-4	71	n	7.1	Tapwater RSL
SODIUM	7440-23-5	NC	--	NC	None
THALLIUM	7440-28-0	0.16	n	0.016	Tapwater RSL
VANADIUM(2)	7440-62-2	78	n	7.8	Tapwater RSL
ZINC	7440-66-6	4700	n	470	Tapwater RSL
TCL VOCs					
1,1- DICHLOROETHANE	75-34-3	2.4	c	2.4	Tapwater RSL
1,1,1-TRICHLOROETHANE	71-55-6	7500	n	750	Tapwater RSL
1,1,2- TRICHLOROETHANE	79-00-5	63	n	6.3	Tapwater RSL
1,1,2,2- TETRACHLORETHANE	79-34-5	0.066	c	0.066	Tapwater RSL
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	76-13-1	53000	n	5300	Tapwater RSL
1,1-DICHLOROETHENE	75-35-4	260	n	26	Tapwater RSL
1,2- DICHLOROBENZENE	95-50-1	280	n	28	Tapwater RSL
1,2- DICHLOROETHANE	107-06-2	0.15	c	0.15	Tapwater RSL
1,2,3-TRICHLOROBENZENE	87-61-6	5.2	n	0.52	Tapwater RSL
1,2,4-TRICHLOROBENZENE	120-82-1	70	n	7	Tapwater RSL
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	0.00032	c	0.00032	Tapwater RSL
1,2-DIBROMOETHANE	106-93-4	0.0065	c	0.0065	Tapwater RSL
1,2-DICHLOROPROPANE	78-87-5	0.38	c	0.38	Tapwater RSL
1,3-DICHLOROBENZENE	541-73-1	NC	--	NC	Tapwater RSL
1,4- DICHLOROBENZENE	106-46-7	0.42	c	0.42	Tapwater RSL
1,4-DIOXANE	123-91-1	0.67	c	0.67	Tapwater RSL
2-BUTANONE	78-93-3	4900	n	490	Tapwater RSL
2-HEXANONE	591-78-6	34	n	3.4	Tapwater RSL
4-METHYL-2-PENTANONE	108-10-1	1000	n	100	Tapwater RSL
ACETONE	67-64-1	12000	n	1200	Tapwater RSL
BENZENE	71-43-2	0.39	c	0.39	Tapwater RSL
BROMOCHLOROMETHANE	74-97-5	83	n	8.3	Tapwater RSL
BROMODICHLOROMETHANE	75-27-4	0.12	c	0.12	Tapwater RSL
BROMOFORM	75-25-2	7.9	c	7.9	Tapwater RSL
BROMOMETHANE	74-83-9	7	n	0.7	Tapwater RSL
CARBON DISULFIDE	75-15-0	720	n	72	Tapwater RSL
CARBON TETRACHLORIDE	56-23-5	0.39	c	0.39	Tapwater RSL
CHLOROBENZENE	108-90-7	72	n	7.2	Tapwater RSL
CHLOROETHANE	75-00-3	21000	n	2100	Tapwater RSL
CHLOROFORM	67-66-3	0.19	c	0.19	Tapwater RSL
CHLOROMETHANE	74-87-3	190	n	19	Tapwater RSL
CIS-1,2- DICHLOROETHENE	156-59-2	28	n	2.8	Tapwater RSL
CIS-1,3- DICHLOROPROPENE(3)	10061-01-5	0.41	c	0.41	Tapwater RSL
CYCLOHEXANE	110-82-7	13000	n	1300	Tapwater RSL
DIBROMOCHLOROMETHANE	124-48-1	0.15	c	0.15	Tapwater RSL
DICHLORODIFLUOROMETHANE	75-71-8	190	n	19	Tapwater RSL
ETHYLBENZENE	100-41-4	1.3	c	1.3	Tapwater RSL
ISOPROPYLBENZENE	98-82-8	390	n	39	Tapwater RSL

HUMAN HEALTH GROUNDWATER SCREENING VALUES

Chemical	CAS #	EPA Tapwater (ug/L)	Basis	Adjusted EPA Tapwater RSL (ug/L)	PAL Reference
METHYL ACETATE	79-20-9	16000	n	1600	Tapwater RSL
METHYL TERT-BUTYL ETHER	1634-04-4	12	c	12	Tapwater RSL
METHYLCYCLOHEXANE	108-87-2	NC	--	NC	Tapwater RSL
METHYLENE CHLORIDE	75-09-2	84	n	8.4	Tapwater RSL
STYRENE	100-42-5	1100	n	110	Tapwater RSL
TETRACHLOROETHENE	127-18-4	35	n	3.5	Tapwater RSL
TOLUENE	108-88-3	860	n	86	Tapwater RSL
O-XYLENE	95-47-6	190	n	19	Tapwater RSL
m,p-XYLENE	108-38-3	190	n	19	Tapwater RSL
TOTAL XYLENES	1330-20-7	190	n	19	Tapwater RSL
TRANS-1,2- DICHLOROETHENE	156-60-5	86	n	8.6	Tapwater RSL
TRANS-1,3-DICHLOROPROPENE	10061-02-6	0.41	c	0.41	Tapwater RSL
TRICHLOROETHENE	79-01-6	2.6	n	0.26	Tapwater RSL
TRICHLOROFLUOROMETHANE	75-69-4	1100	n	110	Tapwater RSL
VINYL CHLORIDE	75-01-4	0.015	c	0.015	Tapwater RSL
TCL SVOCs					
1,1'-BIPHENYL	92-52-4	0.83	n	0.083	Tapwater RSL
1,2,4,5-TETRACHLOROBENZENE	95-94-3	1.2	n	0.12	Tapwater RSL
2,2-OXYBIS(1-CHLOROPROPANE)	108-60-1	0.31	c	0.31	Tapwater RSL
2,3,4,6-TETRACHLOROPHENOL	58-90-2	170	n	17	Tapwater RSL
2,4,5-TRICHLOROPHENOL	95-95-4	890	n	89	Tapwater RSL
2,4,6-TRICHLOROPHENOL	88-06-2	9	n	0.9	Tapwater RSL
2,4-DICHLOROPHENOL	120-83-2	35	n	3.5	Tapwater RSL
2,4-DIMETHYLPHENOL	105-67-9	270	n	27	Tapwater RSL
2,4-DINITROPHENOL	51-28-5	30	n	3	Tapwater RSL
2,4-DINITROTOLUENE	121-14-2	0.2	c	0.2	Tapwater RSL
2,6-DINITROTOLUENE	606-20-2	15	n	1.5	Tapwater RSL
2-CHLORONAPHTHALENE	91-58-7	550	n	55	Tapwater RSL
2-CHLOROPHENOL	95-57-8	71	n	7.1	Tapwater RSL
2-METHYLNAPHTHALENE	91-57-6	27	n	2.7	Tapwater RSL
2-METHYLPHENOL	95-48-7	720	n	72	Tapwater RSL
2-NITROANILINE	88-74-4	150	n	15	Tapwater RSL
2-NITROPHENOL	88-75-5	NC	--	NC	None
3,3'-DICHLOROBENZIDINE	91-94-1	0.11	c	0.11	Tapwater RSL
3-NITROANILINE(4)	99-09-2	3.3	c	3.3	Tapwater RSL
4,6-DINITRO-2-METHYLPHENOL	534-52-1	1.2	n	0.12	Tapwater RSL
4-BROMOPHENYL-PHENYLETHER	101-55-3	NC	--	NC	None
4-CHLORO-3-METHYLPHENOL	59-50-7	1100	n	110	Tapwater RSL
4-CHLOROANILINE	106-47-8	0.32	c	0.32	Tapwater RSL
4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	NC	--	NC	None
4-METHYLPHENOL	106-44-5	1400	n	140	Tapwater RSL
4-NITROANILINE	100-01-6	3.3	c	3.3	Tapwater RSL
4-NITROPHENOL	100-02-7	NC	--	NC	None
ACENAPHTHENE	83-32-9	400	n	40	Tapwater RSL
ACENAPHTHYLENE(5)	208-96-8	400	n	40	Tapwater RSL
ANTHRACENE	120-12-7	1300	n	130	Tapwater RSL
ATRAZINE	1912-24-9	0.26	c	0.26	Tapwater RSL
BENZALDEHYDE	100-52-7	1500	n	150	Tapwater RSL
BENZO (A) ANTHRACENE	56-55-3	0.029	c	0.029	Tapwater RSL
BENZO (A) PYRENE	50-32-8	0.0029	c	0.0029	Tapwater RSL
BENZO (B) FLUOROANTHENE	205-99-2	0.029	c	0.029	Tapwater RSL
BENZO (G,H,I) PERYLENE(6)	191-24-2	87	n	8.7	Tapwater RSL
BENZO (K) FLUOROANTHENE	207-08-9	0.29	c	0.29	Tapwater RSL
BIS(2-CHLOROETHOXY) METHANE	111-91-1	47	n	4.7	Tapwater RSL
BIS-(2-CHLOROETHYL) ETHER	111-44-4	0.012	c	0.012	Tapwater RSL
BIS(2-ETHYLHEXYL) PHTHALATE	117-81-7	0.071	c	0.071	Tapwater RSL
BUTYLBENZYLPHTHALATE	85-68-7	14	c	14	Tapwater RSL
CAPROLACTAM	105-60-2	7700	n	770	Tapwater RSL
CARBAZOLE	86-74-8	NC	--	NC	None
CHRYSENE	218-01-9	2.9	c	2.9	Tapwater RSL
DIBENZO (A,H)-ANTHRACENE	53-70-3	0.0029	c	0.0029	Tapwater RSL
DIBENZOFURAN	132-64-9	5.8	n	0.58	Tapwater RSL
DIETHYLPHTHALATE	84-66-2	11000	n	1100	Tapwater RSL

HUMAN HEALTH GROUNDWATER SCREENING VALUES

Chemical	CAS #	EPA Tapwater (ug/L)	Basis	Adjusted EPA Tapwater RSL (ug/L)	PAL Reference
DIMETHYLPHTHALATE	131-11-3	NC	--	NC	None
DI-N-BUTYLPHTHALATE	84-74-2	670	n	67	Tapwater RSL
DI-N-OCTYLPHTHALATE	117-84-0	NC	--	NC	None
FLUORANTHENE	206-44-0	630	n	63	Tapwater RSL
FLUORENE	86-73-7	220	n	22	Tapwater RSL
HEXACHLOROBENZENE	118-74-1	0.042	c	0.042	Tapwater RSL
HEXACHLOROBUTADIENE	87-68-3	0.26	c	0.26	Tapwater RSL
HEXACHLOROCYCLOPENTADIENE	77-47-4	22	n	2.2	Tapwater RSL
HEXACHLOROETHANE	67-72-1	5.1	n	0.51	Tapwater RSL
INDENO (1,2,3-CD)-PYRENE	193-39-5	0.029	c	0.029	Tapwater RSL
ISOPHORONE	78-59-1	67	c	67	Tapwater RSL
NAPHTHALENE	91-20-3	0.14	c	0.14	Tapwater RSL
NITROBENZENE	98-95-3	0.12	c	0.12	Tapwater RSL
N-NITROSO DIPHENYLAMINE	86-30-6	10	c	10	Tapwater RSL
N-NITROSO-DI-N PROPYLAMINE	621-64-7	0.0093	c	0.0093	Tapwater RSL
PENTACHLOROPHENOL	87-86-5	0.17	c	0.17	Tapwater RSL
PHENANTHRENE[6]	85-01-8	87	n	8.7	Tapwater RSL
PHENOL	108-95-2	4500	n	450	Tapwater RSL
PYRENE	129-00-0	87	n	8.7	Tapwater RSL
TCL Pesticides					
4,4'-DDD	72-54-8	0.28	c	0.28	Tapwater RSL
4,4'-DDE	72-55-9	0.2	c	0.2	Tapwater RSL
4,4'-DDT	50-29-3	0.2	c	0.2	Tapwater RSL
ALDRIN	309-00-2	0.00021	c	0.00021	Tapwater RSL
ALPHA-BHC	319-84-6	0.0062	c	0.0062	Tapwater RSL
ALPHA-CHLORDANE[7]	5103-71-9	0.027	c	0.027	Tapwater RSL
BETA-BHC	319-85-7	0.022	c	0.022	Tapwater RSL
DELTA-BHC	319-86-8	NC	--	NC	None
DIELDRIN	60-57-1	0.0015	c	0.0015	Tapwater RSL
ENDOSULFAN I[8]	959-98-8	78	n	0.78	Tapwater RSL
ENDOSULFAN II[8]	33213-65-9	78	n	0.78	Tapwater RSL
ENDOSULFAN SULFATE[8]	1031-07-8	78	n	0.78	Tapwater RSL
ENDRIN	72-20-8	1.7	n	0.17	Tapwater RSL
ENDRIN ALDEHYDE[9]	7421-93-4	1.7	n	0.17	Tapwater RSL
ENDRIN KETONE[9]	53494-70-5	1.7	n	0.17	Tapwater RSL
GAMMA-BHC (LINDANE)	58-89-9	0.036	c	0.036	Tapwater RSL
GAMMA-CHLORDANE[7]	5103-74-2	0.027	c	0.027	Tapwater RSL
HEPTACHLOR	76-44-8	0.0018	c	0.0018	Tapwater RSL
HEPTACHLOR EPOXIDE	1024-57-3	0.0033	c	0.0033	Tapwater RSL
METHOXYCHLOR	72-43-5	27	n	2.7	Tapwater RSL
TOXAPHENE	8001-35-2	0.013	c	0.013	Tapwater RSL
TCL PCBs					
AROCLOR-1016	12674-11-2	1.1	n	0.11	Tapwater RSL
AROCLOR-1221	11104-28-2	0.0043	c	0.0043	Tapwater RSL
AROCLOR-1232	11141-16-5	0.0043	c	0.0043	Tapwater RSL
AROCLOR-1242	53469-21-9	0.034	c	0.034	Tapwater RSL
AROCLOR-1248	12672-29-6	0.034	c	0.034	Tapwater RSL
AROCLOR-1254	11097-69-1	0.31	n	0.031	Tapwater RSL
AROCLOR-1260	11096-82-5	0.034	c	0.034	Tapwater RSL
AROCLOR-1262	37324-23-5	NC	--	NC	None
AROCLOR-1268	11100-14-4	NC	--	NC	None
EXPLOSIVES					
1,3,5-Trinitrobenzene	99-35-4	460	n	46	Tapwater RSL
1,3-Dinitrobenzene	99-65-0	1.5	n	0.15	Tapwater RSL
2,4-Dinitrotoluene	121-14-2	0.2	c	0.2	Tapwater RSL
2,6-Dinitrotoluene	606-20-2	15	n	1.5	Tapwater RSL
Nitrobenzene	98-95-3	0.12	c	0.12	Tapwater RSL
2,4,6-Trinitrotoluene	118-96-7	7.6	n	0.76	Tapwater RSL
2-Amino-4,6-Dinitrotoluene	35572-78-2	30	n	3	Tapwater RSL
2-Nitrotoluene	88-72-2	0.27	c	0.27	Tapwater RSL
3-Nitrotoluene	99-08-1	1.3	n	0.13	Tapwater RSL
3,5-Dinitroaniline	618-87-1	NC	--	NC	None
4-Amino-2,6-Dinitrotoluene	19406-51-0	30	n	3	Tapwater RSL

HUMAN HEALTH GROUNDWATER SCREENING VALUES

Chemical	CAS #	EPA Tapwater (ug/L)	Basis	Adjusted EPA Tapwater RSL (ug/L)	PAL Reference
4-Nitrotoluene	99-99-0	3.7	c	3.7	Tapwater RSL
HMX	2691-41-0	780	n	78	Tapwater RSL
Tetryl	479-45-8	63	n	6.3	Tapwater RSL
RDX	121-82-4	0.61	c	0.61	Tapwater RSL
PETN	78-11-5	30	n	3	Tapwater RSL
Nitroglycerin	55-63-0	1.5	n	0.15	Tapwater RSL

The USEPA RSL (May, 2012) tap water RSLs for noncarcinogens adjusted by dividing by 10, equivalent to a target hazard quotient of 0.1. The tap water RSL for carcinogens (not adjusted) is equivalent to an incremental lifetime cancer risk (ILCR) of 1E-6.

Footnotes:
1) The value for hexavalent chromium is presented
2) The value presented is for vanadium and compounds.
3) The value for 1,3-dichloropropene is presented.
4) The value for 4-nitroaniline is presented.
5) The value for acenaphthene is presented.
6) The value for pyrene is presented.
7) The value for chlordane is presented.
8) The value for endosulfan is presented.
9) The value for endrin is presented.

Acronyms:
c- carcinogenic
CAS - Chemical Abstract Service
EPA - United States Environmental Protection Agency
MCL - Maximum Contaminant Level
n - noncarcinogenic
NC - No Criteria
PAL - Project Action Limit
PCB - Polychlorinated Biphenyl
RSL - Regional Screening Level
SVOC - Semi-Volatile Organic Compound
TAL - Target Analyte List
TCL - Target Compound List
µg/L - micrograms per liter
VOC - Volatile Organic Compound

Comparision of the 2010 to 2012 proposed
Maine Remedial Action Guidelines (RAGs) for Soil

2012 CAS_Number	2012 Chemical	2010 Leaching to Groundwater	2012 Leaching to Groundwater	2010 Residential	2012 Residential	2010 Park User	2012 Park User	2010 Outdoor Commercial Worker	2012 Outdoor Commercial Worker	2010 Excavation or Construction Worker	2012 Excavation or Construction Worker	2010 Soil Rural Background	2012 Soil Rural Background	2012 Soil urban Background
630-20-6	1,1,1,2-Tetrachloroethane	0.28	0.28	540	550	900	910	1700	1,800	9,300	9,300			
79-34-5	1,1,2,2-Tetrachloroethane	0.022	0.022	68	71	110	120	210	240	900	2,200			
71-55-6	1,1,1-Trichloroethane	730	730	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
79-00-5	1,1,2-Trichloroethane			240	250	410	410	790	830	4,200	5,400			
92-52-4	1,1-Biphenyl			8,500	8,500	10,000	10,000	10,000	10,000	10,000	10,000			
75-34-3	1,1-Dichloroethane	0.98	0.98	2,500	2,500	4,100	4,100	8,200	8,400	10,000	10,000			
75-35-4	1,1-Dichloroethene	2.2	2.2	8,500	8,500	10,000	10,000	10,000	10,000	10,000	10,000			
87-61-6	1,2,3-Trichlorobenzene			1,500	1,700	2,500	2,800	7,200	10,000	200	420			
120-82-1	1,2,4-Trichlorobenzene	8.6	8.6	1,500	490	2,600	820	7,400	1,600	210	430			
96-12-8	1,2-Dibromo-3-chloropropane			3	3	5	5	18	52	20	78			
95-50-1	1,2-Dichlorobenzene	12	12	5,100	5,100	8,500	8,500	10,000	10,000	10,000	10,000			
107-06-2	1,2-Dichloroethane	0.36	0.36	150	160	250	260	470	520	2,000	3,700			
156-59-2	1,2-Dichloroethene (cis)	0.98	0.98	1,700	340	2,800	570	10,000	3,400	10,000	6,200			
156-60-5	1,2-Dichloroethene (trans)	3.3	3.3	3,400	3,400	5,700	5,700	10,000	10,000	10,000	10,000			
78-87-5	1,2-Dichloropropane			390	390	650	650	1,300	1,300	4,800	5,200			
528-29-0	1,2-Dinitrobenzene			13	13	22	22	100	100	240	240			
106-99-0	1,3-Butadiene			4	4	7	7	14	14	130	130			
541-73-1	1,3-Dichlorobenzene	1.1	1.1	340	34	570	57	3,400	340	6,200	6,200			
142-28-9	1,3-Dichloropropane			3,400	3,400	5,700	5,700	10,000	10,000	10,000	10,000			
542-75-6	1,3-Dichloropropene			140	140	240	240	470	480	4,100	4,300			
99-65-0	1,3-Dinitrobenzene			13	13	22	22	100	100	120	120			
106-46-7	1,4-Dichlorobenzene	4	4	2,200	2,600	3,600	4,300	5,300	8,500	9,500	10,000			
100-25-4	1,4-Dinitrobenzene			13	13	22	22	100	100	240	240			
123-91-1	1,4-Dioxane			980	110	1,600	180	2,600	290	10,000	3,300			
93-76-5	2,4,5-T			1,300	1,300	2,200	2,200	10,000	10,000	10,000	10,000			
93-72-1	2,4,5-TP				1,100		1,800		8,200		1,900			
95-95-4	2,4,5-Trichlorophenol			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
88-06-2	2,4,6-Trichlorophenol			130	130	220	220	1,000	1,000	240	240			
118-96-7	2,4,6-Trinitrotoluene			67	67	110	110	510	510	120	120			
120-83-2	2,4-Dichlorophenol			400	400	670	670	3,100	3,100	710	710			
105-67-9	2,4-Dimethylphenol			2,700	2,700	4,400	4,400	10,000	10,000	10,000	10,000			
51-28-5	2,4-Dinitrophenol			270	270	440	440	2,100	2,100	4,800	4,800			
121-14-2	2,4-Dinitrotoluene			35	35	58	58	93	93	480	480			
576-26-1	2,6-Dimethylphenol			80	80	130	130	620	620	1,400	1,400			
606-20-2	2,6-Dinitrotoluene			16	16	26	26	42	42	490	490			
95-57-8	2-Chlorophenol			850	850	1,400	1,400	8,500	8,500	2,500	2,500			
95-48-7	2-Cresol			6,700	6,700	10,000	10,000	10,000	10,000	10,000	10,000			
91-57-6	2-Methylnaphthalene	3.6	3.6	470	500	790	830	2,400	3,600	170	600		0.414	0.804
91-94-1	3,3-Dichlorobenzidine			24	24	40	40	64	64	740	740			
108-39-4	3-Cresol			6,700	6,700	10,000	10,000	10,000	10,000	10,000	10,000			
106-47-8	4-Chloroaniline			54	54	90	90	140	140	120	120			
106-44-5	4-Cresol			670	670	1,100	1,100	5,100	5,100	10,000	10,000			
83-32-9	Acenaphthene	170	170	4,800	7,500	8,100	10,000	9,900	10,000	560	9,800		0.479	0.6072
208-96-8	Acenaphthylene	68	68	5,100	7,500	8,500	10,000	10,000	10,000	660	10,000		0.4937	0.6606
67-64-1	Acetone			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
107-02-8	Acrolein			83	85	140	140	620	850	280	1,200			
107-13-1	Acrylonitrile			26	26	43	44	85	88	190	800			
15972-60-8	Alachlor			190	190	320	320	510	510	2,400	2,400			
309-00-2	Aldrin			1	1	1	1	2	2	10	10			
107-05-1	Allyl chloride			670	680	1,100	1,100	2,200	2,300	5,600	10,000			
7429-90-5	Aluminum			170,000	170,000	280,000	280,000	1,700,000	1,000,000	310,000	310,000	69,000	63,000	
120-12-7	Anthracene	2,400	2,400	10,000	10,000	10,000	10,000	10,000	10,000	2,200	3,800		0	1.63
7440-36-0	Antimony			68	68	110	110	680	680	120	120	1	1	
7440-36-0	Antimony			68	68	110	110	680	680	120	120	1	1	
7440-38-2	Arsenic			1	1	2	2	4	4	42	42	9	15	
	Atrazine			47	47	78	78	120	120	710	710			

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7440-39-3	Barium			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	740	490	
71-43-2	Benzene	0.51	0.51	85	85	140	140	850	850	150	150			
56-55-3	Benzo(a)anthracene			3	3	4	4	35	35	430	430		2	4.15
50-32-8	Benzo(a)pyrene			0	0	0	0	4	4	43	43		2	4.57
205-99-2	Benzo(b)fluoranthene			3	3	4	4	35	35	430	430		3	5.335
191-24-2	Benzo(g,h,i)perylene			3,700	3,700	6,200	6,200	10,000	10,000	10,000	10,000		1	2.035
207-08-9	Benzo(k)fluoranthene			26	26	44	44	350	350	4,300	4,300		2	3.225
100-44-7	Benzyl chloride			80	83	130	140	240	280	50	620			
7440-41-7	Beryllium			340	340	570	570	3,400	3,400	620	620	2	3	
117-81-7	bis(2-Ethylhexyl)phthalate			770	770	1,300	1,300	2,100	2,100	10,000	10,000			
75-27-4	Bromodichloromethane			220	230	370	380	680	760	2,700	5,200			
75-25-2	Bromoform			1,400	1,400	2,300	2,300	3,600	3,600	10,000	10,000			
74-83-9	Bromomethane			240	240	390	400	2,000	2,400	850	930			
85-68-7	Butyl benzyl phthalate			5,700	5,700	9,500	9,500	10,000	10,000	10,000	10,000			
7440-43-9	Cadmium			11	11	18	18	94	94	19	19	1	0	
75-15-0	Carbon disulfide			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
56-23-5	Carbon tetrachloride	0.3	0.3	110	200	180	340	360	680	2,000	2,800			
57-74-9	Chlordane			36	36	60	60	110	110	170	170			
108-90-7	Chlorobenzene	1.5	1.5	3,400	3,400	5,700	5,700	10,000	10,000	10,000	10,000			
67-66-3	Chloroform			450	460	750	760	1,400	1,500	7,400	10,000			
16065-83-1	Chromium (+3)			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
18540-29-9	Chromium (+6)			510	510	850	850	5,100	5,100	2,800	2,800			
218-01-9	Chrysene			260	260	440	440	3,500	3,500	10,000	10,000		4	4.1
7440-48-4	Cobalt			51	51	85	85	510	510	920	920	15	15	
7440-50-8	Copper			2,400	2,400	4,000	4,000	10,000	10,000	4,300	4,300	23	28	
57-12-5	Cyanide			3,400	100	5,700	170	10,000	1,000	10,000	1,900			
72-54-8	DDD			45	45	75	75	120	120	1,400	1,400			
72-55-9	DDE			32	32	53	53	85	85	980	980			
50-29-3	DDT			38	38	64	64	120	120	140	140			
53-70-3	Dibenz(a,h)anthracene			0	0	0	0	4	4	43	43			
124-48-1	Dibromochloromethane			160	170	270	280	520	560	2,500	4,300			
84-74-2	Dibutyl phthalate			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
75-71-8	Dichlorodifluoromethane			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
84-66-2	Diethyl phthalate			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
60-57-1	Dieldrin			1	1	1	1	2	2	21	21			
88-85-7	Dinoseb			130	130	220	220	1,000	1,000	240	240			
1746-01-6	Dioxin-Like Compounds - TEQ			0	0	0	0	0	0	0	0			
115-29-7	Endosulfan			800	800	1,300	1,300	6,200	6,200	1,400	1,400			
72-20-8	Endrin			40	40	67	67	310	310	480	480			
100-41-4	Ethylbenzene	0.81	0.81	1,300	1,300	2,100	2,200	4,200	4,300	10,000	10,000			
106-93-4	Ethylene dibromide			7	7	12	12	22	24	110	160			
75-00-3	Ethyl chloride			1,700	1,700	2,800	2,800	10,000	10,000	10,000	10,000			
206-44-0	Fluoranthene			5,000	5,000	8,300	8,300	10,000	10,000	10,000	10,000		4	7.635
86-73-7	Fluorene	120	120	4,100	5,000	6,900	8,300	10,000	10,000	1,000	10,000		0	0.708
76-44-8	Heptachlor			1	1	2	2	6	6	24	24			
1024-57-3	Heptachlor epoxide			1	1	2	2	3	3	3	3			
118-74-1	Hexachlorobenzene			7	7	11	11	18	18	24	24			
87-68-3	Hexachlorobutadiene			130	130	220	220	370	370	240	240			
319-84-6	Hexachlorocyclohexane, alpha (alpha-BHC)			2	2	3	3	5	5	53	53			
319-85-7	Hexachlorocyclohexane, beta (beta-BHC)			6	6	10	10	16	16	140	140			
58-89-9	Hexachlorocyclohexane, gamma (Lindane)			1	1	1	1	5	5	3	3			
67-72-1	Hexachloroethane			130	93	220	160	1,000	720	2,400	2,400			
121-82-4	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)			98	98	160	160	260	260	3,000	3,000			
193-39-5	Indeno(1,2,3-cd)pyrene			3	3	4	4	35	35	430	430		2	2.6
7439-89-6	Iron			120,000	120,000	200,000	200,000	1,200,000	1,000,000	220,000	220,000	31,000	40,000	

Comparision of the 2010 to 2012 proposed
Maine Remedial Action Guidelines (RAGs) for Soil

2012 CAS_Number	2012 Chemical	2010 Leaching to Groundwater	2012 Leaching to Groundwater	2010 Residential	2012 Residential	2010 Park User	2012 Park User	2010 Outdoor Commercial Worker	2012 Outdoor Commercial Worker	2010 Excavation or Construction Worker	2012 Excavation or Construction Worker	2010 Soil Rural Background	2012 Soil Rural Background	2012 Soil urban Background
7439-92-1	Lead			340	340	530	530	1,100	1,100	950	950			
121-75-5	Malathion			2,700	2,700	4,400	4,400	10,000	10,000	4,800	4,800			
7439-96-5	Manganese			4,100	4,100	6,800	6,800	10,000	10,000	7,400	7,400	1,100	1,100	
7487-94-7	Mercuric chloride & other inorganic mercury compounds			51	51	85	85	510	510	930	930	0.084		
72-43-5	Methoxychlor			670	670	1,100	1,100	5,100	5,100	1,200	1,200			
78-93-3	Methyl ethyl ketone			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
108-10-1	Methyl isobutyl ketone			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
80-62-6	Methyl methacrylate			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
1634-04-4	Methyl tert-butyl ether	0.19	0.19	5,100	5,100	8,500	8,500	10,000	10,000	10,000	10,000			
75-09-2	Methylene chloride			1,900	1,900	3,100	3,200	6,300	6,400	10,000	10,000			
7439-98-7	Molybdenum			850	850	1,400	1,400	8,500	8,500	1,500	1,500			
106-94-5	n-Propyl bromide			240	240	390	400	2,000	2,400	850	930			
91-20-3	Naphthalene	1.7	1.7	1,900	2,500	3,200	4,200	2,000	10,000	160	10,000		0.41	0.8368
7440-2-0	Nickel			510	510	850	850	5,100	5,100	930	930	28	43	
2691-41-0	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetra (HMX)			6,700	6,700	10,000	10,000	10,000	10,000	10,000	10,000			
56-38-2	Parathion			800	800	1,300	1,300	6,200	6,200	1,400	1,400			
1336-36-3	PCBs			2	2	4	4	12	12	7	7			
87-86-5	Pentachlorophenol			66	20	110	33	150	45	180	620			
14797-73-0	Perchlorate			20	20	34	34	200	200	37	37			
85-01-8	Phenanthrene	97	97	3,500	3,700	5,900	6,200	10,000	10,000	2,300	8,900		1.608	4.064
108-95-2	Phenol			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
129-00-0	Pyrene			3,700	3,700	6,200	6,200	10,000	10,000	10,000	10,000		4.016	6.71
7782-49-2	Selenium			340	850	570	1,400	3,400	8,500	1,500	1,500	0.9	0.8	
7440-22-4	Silver			850	850	1,400	1,400	8,500	8,500	1,500	1,500			
100-42-5	Styrene			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
127-18-4	Tetrachloroethene	0.43	0.43	26	26	44	44	88	88	790	800			
298-2-2	Thimet (Phorate)			27	27	44	44	210	210	48	48			
108-88-3	Toluene	8.1	8.1	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
79-1-6	Trichloroethene	1.5	1.5	1,100	85	1,800	140	3,600	850	10,000	140			
75-69-4	Trichlorofluoromethane			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
7440-62-2	Vanadium			1,200	1,200	2,000	2,000	10,000	10,000	2,200	2,200	93	100	
108-05-4	Vinyl acetate			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
75-1-4	Vinyl chloride	0.16	0.16	1	1	1	1	66	66	600	600			
1330-20-7	Xylene	26	26	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000			
7440-66-6	Zinc			10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	94	100	

ECOLOGICAL SOIL SCREENING VALUES

Chemical	Chemical Abstract Service (CAS) No.	Final Ecological Screening Level	Source of Final Ecological Screening Level
METALS (mg/kg)			
ALUMINUM	7429-90-5	50	ORNL Plant
Antimony	7440-36-0	0.27	EPA SSL Wildlife
Arsenic	7440-38-2	18	EPA SSL Plant
BARIUM	7440-39-3	330	EPA SSL Invert
BERYLLIUM	7440-41-7	10	ORNL Plant
CADMIUM	7440-43-9	0.36	EPA SSL Wildlife
CALCIUM	7440-70-2	NA	NA
CHROMIUM	7440-47-3	0.4	ORNL Invert
COBALT	7440-48-4	13	EPA SSL Plant
Copper	7440-50-8	28	EPA SSL Wildlife
IRON	7439-89-6	200	ORNL Invert
Lead	7439-92-1	11	EPA SSL Wildlife
MERCURY	7439-97-6	0.1	ORNL Invert
MAGNESIUM	7439-95-4	NA	NA
MANGANESE	7439-96-5	220	EPA SSL Plant
NICKEL	7440-02-0	38	EPA SSL Plant
POTASSIUM	7440-09-7	NA	NA
SELENIUM	7782-49-2	0.52	EPA SSL Plant
SILVER	7440-22-4	4.2	EPA SSL Wildlife
SODIUM	7440-23-5	NA	NA
THALLIUM	7440-28-0	0.0569	Region 5 Wildlife
VANADIUM	7440-62-2	2	ORNL Plant
Zinc	7440-66-6	46	EPA SSL Wildlife
TCL VOCs (MG/KG)			
1,1,1-TRICHLOROETHANE	71-55-6	0.07	Target Value
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	76-13-1	NA	NA
1,1,2,2- TETRACHLORETHANE	79-34-5	0.127	Region 5 Wildlife
1,1,2- TRICHLOROETHANE	79-00-5	0.4	Target Value
1,1- DICHLOROETHANE	75-34-3	0.02	Target Value
1,1-DICHLOROETHENE	75-35-4	0.1	Target Value
1,2,3-TRICHLOROBENZENE	87-61-6	20	ORNL Invert
1,2,4-TRICHLOROBENZENE	120-82-1	11.1	Region 5 Wildlife
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	0.0352	Region 5 Wildlife
1,2-DIBROMOETHANE	106-93-4	1.23	Region 5 Wildlife
1,2- DICHLOROBENZENE	95-50-1	2.96	Region 5 Wildlife
1,2- DICHLOROETHANE	107-06-2	0.02	Target Value
1,2-DICHLOROPROPANE	78-87-5	0.002	Target Value
1,3-DICHLOROBENZENE	541-73-1	37.7	Region 5 Wildlife
1,4- DICHLOROBENZENE	106-46-7	0.546	Region 5 Wildlife
1,4-DIOXANE	123-91-1	2.05	Region 5 Wildlife
2-BUTANONE	78-93-3	89.6	Region 5 Wildlife
2-HEXANONE	591-78-6	12.6	Region 5 Wildlife
4-METHYL-2-PENTANONE	108-10-1	443	Region 5 Wildlife
ACETONE	67-64-1	2.5	Region 5 Wildlife
BENZENE	71-43-2	25	CCME Wildlife
BROMODICHLOROMETHANE	75-27-4	0.54	Region 5 Wildlife
BROMOCHLOROMETHANE	74-97-5	NA	NA
BROMOFORM	75-25-2	15.9	Region 5 Wildlife
BROMOMETHANE	74-83-9	0.235	Region 5 Wildlife
CARBON DISULFIDE	75-15-0	0.0941	Region 5 Wildlife
CARBON TETRACHLORIDE	56-23-5	2.98	Region 5 Wildlife
CHLOROBENZENE	108-90-7	0.03	Target Value
CHLOROETHANE	75-00-3	NA	NA
CHLOROFORM	67-66-3	1.19	Region 5 Wildlife
CHLOROMETHANE	74-87-3	10.4	Region 5 Wildlife
CIS-1,2- DICHLOROETHENE	156-59-2	0.2	Target Value
CIS-1,3- DICHLOROPROPENE	10061-01-5	0.2	Target Value
CYCLOHEXANE	110-82-7	NA	NA
DIBROMOCHLOROMETHANE	124-48-1	2.05	Region 5 Wildlife
DICHLORODIFLUOROMETHANE	75-71-8	39.5	Region 5 Wildlife
ETHYLBENZENE	100-41-4	5.16	Region 5 Wildlife
ISOPROPYLBENZENE	98-82-8	NA	NA
METHYL ACETATE	79-20-9	NA	NA
METHYLCYCLOHEXANE	108-87-2	NA	NA
METHYLENE CHLORIDE	75-09-2	4.05	Region 5 Wildlife
METHYL TERT-BUTYL ETHER	1634-04-4	NA	NA
STYRENE	100-42-5	1.2	LANL Invert
TETRACHLOROETHENE	127-18-4	0.002	Target Value
TOLUENE	108-88-3	75	CCME
TRANS-1,2- DICHLOROETHENE	156-60-5	0.2	Target Value
TRANS-1,3-DICHLOROPROPENE	10061-02-6	0.2	Target Value
TRICHLOROETHENE	79-01-6	0.1	Target Value
TRICHLOROFLUOROMETHANE	75-69-4	16.4	Region 5 Wildlife
VINYL CHLORIDE	75-01-4	0.01	Target Value
O-XYLENE	95-94-6	95	CCME Plant/Invert.
m,p-XYLENE	179601-23-1	95	CCME Plant/Invert.
TCL SVOCs (MG/KG)			
1,1'-BIPHENYL	92-52-4	60	ORNL Plant
1,2,4,5-TETRACHLOROBENZENE	95-94-3	2.02	Region 5 Wildlife
2,2-OXYBIS(1-CHLOROPROPANE)	108-60-1	19.9	Region 5 Wildlife

ECOLOGICAL SOIL SCREENING VALUES

Chemical	Chemical Abstract Service (CAS) No.	Final Ecological Screening Level	Source of Final Ecological Screening Level
2,3,4,6-TETRACHLOROPHENOL	58-90-2	0.199	Region 5 Wildlife
2,4,5-TRICHLOROPHENOL	95-95-4	4	ORNL Plant
2,4,6-TRICHLOROPHENOL	88-06-2	9.94	Region 5 Wildlife
2,4-DICHLOROPHENOL	120-83-2	87.5	Region 5 Wildlife
2,4-DIMETHYLPHENOL	105-67-9	NA	NA
2,4-DINITROPHENOL	51-28-5	0.0609	Region 5 Wildlife
2,4-DINITROTOLUENE	121-14-2	1.28	Region 5 Wildlife
2,6-DINITROTOLUENE	606-20-2	0.0328	Region 5 Wildlife
2-CHLORONAPHTHALENE	91-58-7	0.0122	Region 5 Wildlife
2-CHLOROPHENOL	95-57-8	0.243	Region 5 Wildlife
2-METHYLNAPHTHALENE	91-57-6	29	EPA SSL Invert
2-METHYLPHENOL	95-48-7	0.05	Target Value
2-NITROANILINE	88-74-4	74.1	Region 5 Wildlife
2-NITROPHENOL	88-75-5	1.6	Region 5 Wildlife
3,3'-DICHLOROBENZIDINE	91-94-1	0.646	Region 5 Wildlife
3-NITROANILINE	99-09-2	3.16	Region 5 Wildlife
4,6-DINITRO-2-METHYLPHENOL	534-52-1	0.144	Region 5 Wildlife
4-BROMOPHENYL-PHENYLETHER	101-55-3	NA	NA
4-CHLORO-3-METHYLPHENOL	59-50-7	7.95	Region 5 Wildlife
4-CHLOROANILINE	106-47-8	1	LANL Plant
4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	NA	NA
4-METHYLPHENOL	106-44-5	0.05	Target Value
4-NITROANILINE	100-01-6	21.9	Region 5 Wildlife
4-NITROPHENOL	100-02-7	5.12	Region 5 Wildlife
ACENAPHTHENE	83-32-9	20	ORNL Plant
ACENAPHTHYLENE	208-96-8	29	EPA SSL Invert
ANTHRACENE	120-12-7	6.8	LANL Plant
ATRAZINE	1912-24-9	NA	NA
BENZALDEHYDE	100-52-7	NA	NA
BENZO (A) ANTHRACENE	56-55-3	1.1	EPA SSL Wildlife
BENZO (A) PYRENE	50-32-8	1.1	EPA SSL Wildlife
BENZO (B) FLUOROANTHENE	205-99-2	1.1	EPA SSL Wildlife
BENZO (G,H,I) PERYLENE	191-24-2	1.1	EPA SSL Wildlife
BENZO (K) FLUOROANTHENE	207-08-9	1.1	EPA SSL Wildlife
BIS(2-CHLOROETHOXY) METHANE	111-91-1	0.302	Region 5 Wildlife
BIS-(2-CHLOROETHYL) ETHER	111-44-4	23.7	Region 5 Wildlife
BIS(2-ETHYLHEXYL) PHTHALATE	117-81-7	0.925	Region 5 Wildlife
BUTYLBENZYLPHTHALATE	85-68-7	0.239	Region 5 Wildlife
CAPROLACTAM	105-60-2	NA	NA
CARBAZOLE	86-74-8	NA	NA
CHRYSENE	218-01-9	1.1	EPA SSL Wildlife
DIBENZO (A,H)-ANTHRACENE	53-70-3	0.1	CCME Plant/Inver
DIBENZOFURAN	132-64-9	6.1	LANL Plant
DIETHYLPHTHALATE	84-66-2	24.8	Region 5 Wildlife
DIMETHYLPHTHALATE	131-11-3	200	ORNL Plant
DI-N-BUTYLPHTHALATE	84-74-2	0.15	Region 5 Wildlife
DI-N-OCTYLPHTHALATE	117-84-0	709	Region 5 Wildlife
FLUORANTHENE	206-44-0	29	EPA SSL Invert
FLUORENE	86-73-7	29	EPA SSL Invert
HEXACHLOROBENZENE	118-74-1	0.199	Region 5 Wildlife
HEXACHLOROBUTADIENE	87-68-3	0.0398	Region 5 Wildlife
HEXACHLOROCYCLOPENTADIENE	77-47-4	0.755	Region 5 Wildlife
HEXACHLOROETHANE	67-72-1	0.596	Region 5 Wildlife
INDENO (1,2,3-CD)-PYRENE	193-39-5	0.1	CCME Plant/Inver
ISOPHORONE	78-59-1	139	Region 5 Wildlife
NAPHTHALENE	91-20-3	1	LANL Plant
NITROBENZENE	98-95-3	1.31	Region 5 Wildlife
N-NITROSO DIPHENYLAMINE	86-30-6	0.545	Region 5 Wildlife
N-NITROSO-DI-N PROPYLAMINE	621-64-7	0.544	Region 5 Wildlife
PENTACHLOROPHENOL	87-86-5	2.1	EPA SSL Wildlife
PHENANTHRENE	85-01-8	29	EPA SSL Invert
PHENOL	108-95-2	30	ORNL Invert
PYRENE	129-00-0	1.1	EPA SSL Wildlife
EXPLOSIVES (MG/KG)			
1,3,5-Trinitrobenzene	99-35-4	0.376	Region 5 Wildlife
1,3-Dinitrobenzene	99-65-0	0.655	Region 5 Wildlife
2,4-Dinitrotoluene	121-14-2	1.28	Region 5 Wildlife
2,6-Dinitrotoluene	606-20-2	0.0328	Region 5 Wildlife
Nitrobenzene	98-95-3	1.31	Region 5 Wildlife
2,4,6-Trinitrotoluene	118-96-7	6	Sunahara Plant
2-Amino-4,6-Dinitrotoluene	35572-78-2	80	LANL Plant
2-Nitrotoluene	88-72-2	NA	NA
3-Nitrotoluene	99-08-1	NA	NA
3,5-Dinitroaniline	618-87-1	NA	NA
4-Amino-2,6-Dinitrotoluene	1946-51-0	80	LANL Plant
4-Nitrotoluene	99-99-0	NA	NA
HMX	2691-41-0	600	Sunahara Invert
Tetryl	479-45-8	25	LANL Plant
RDX	121-82-4	98	Sunahara Invert
PETN	78-11-5	NA	NA
Nitroglycerin	55-63-0	NA	NA

ECOLOGICAL SOIL SCREENING VALUES

Chemical	Chemical Abstract Service (CAS) No.	Final Ecological Screening Level	Source of Final Ecological Screening Level
PCBs (MG/KG)			
AROCLOR-1016	12674-11-2	1.3	CCME Wildlife
AROCLOR-1221	11104-28-2	1.3	CCME Wildlife
AROCLOR-1232	11141-16-5	1.3	CCME Wildlife
AROCLOR-1242	53469-21-9	1.3	CCME Wildlife
AROCLOR-1248	12672-29-6	1.3	CCME Wildlife
AROCLOR-1254	11097-69-1	1.3	CCME Wildlife
AROCLOR-1260	11096-82-5	1.3	CCME Wildlife
AROCLOR-1262	37324-23-5	1.3	CCME Wildlife
AROCLOR-1268	11100-14-4	1.3	CCME Wildlife
TCL Pesticides (MG/KG)			
4,4'-DDD	72-54-8	0.021	EPA SSL Wildlife
4,4'-DDE	72-55-9	0.021	EPA SSL Wildlife
4,4'-DDT	50-29-3	0.021	EPA SSL Wildlife
ALDRIN	309-00-2	0.00006	Target Value
ALPHA-BHC	319-84-6	0.003	Target Value
ALPHA-CHLORDANE	5103-71-9	0.00003	Target Value
BETA-BHC	319-85-7	0.009	Target Value
DELTA-BHC	319-86-8	9.94	Region 5 Wildlife
DIELDRIN	60-57-1	0.0005	Target Value
ENDOSULFAN I	959-98-8	0.00001	Target Value
ENDOSULFAN II	33213-65-9	0.00001	Target Value
ENDOSULFAN SULFATE	1031-07-8	0.00001	Target Value
ENDRIN	72-20-8	0.00004	Target Value
ENDRIN ALDEHYDE	7421-93-4	0.00004	Target Value
ENDRIN KETONE	53494-70-5	0.00004	Target Value
GAMMA-BHC (LINDANE)	58-89-9	0.00005	Target Value
GAMMA-CHLORDANE	5103-74-2	0.00003	Target Value
HEPTACHLOR	76-44-8	0.0007	Target Value
HEPTACHLOR EPOXIDE	1024-57-3	0.0000002	Target Value
METHOXYCHLOR	72-43-5	0.0199	Region 5 Wildlife
TOXAPHENE	8001-35-2	0.119	Region 5 Wildlife

The selected ecological SSLs are the lowest of the selected benchmarks for plants, invertebrates, and wildlife.
The benchmarks were selected by order of preference according to the following hierarchy:

Screening Level Order of Preference for plants and invertebrates:

1. USEPA Eco SSL - EPA Ecological Soil Screening Levels (EPA SSL Plant or Invert)
2a. ORNL Benchmark (Efroymson, 1997a) - Oak Ridge National Laboratory Plant Toxicological Benchmark (ORNL Plant)
2b. ORNL Benchmark (Efroymson, 1997b) - Oak Ridge National Laboratory Invertebrate Toxicological Benchmark (ORNL Invert)
3. CCME - Canadian Council and Ministers of Environment (CCME Plant/Invert)
4. Sunahara (Sunahara et al, 2009)
5 LANL (2011)
6. Target Value - Ministry of Housing, Spacial Planning and Environment

Screening Level Order of Preference for wildlife:

1. USEPA Eco SSL - EPA Ecological Soil Screening Levels (EPA SSL Wildlife)
2 CCME - Canadian Council and Ministers of Environment (CCME Wildlife) (presented only if no EPA SSL is available)
3. USEPA Region 5 ESL - EPA Region 5 Ecological Screening Levels (Region 5 ESL)

Abbreviations:

CCME - Canadian Council and Ministers of Environment
Eco SSL - USEPA Ecological Soil Screening Level
LANL - Los Alamos National Lab Ecorisk Database (Release 2.4)
NA = Not Available
ORNL - OakRidge National Laboratory
SSL - Soil Screening Level
USEPA = United States Environmental Protection Agency

References:

CCME, 1999. Canadian soil quality guidelines for the protection of environmental and human health. (Separate documents for each chemical).

Efroymson, R.A., M.E. Will, and G.W. Suter II, 1997a. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory. November. ES/ER/TM-126/R2.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, 1997b. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory. November. ES/ER/TM-85/R3.

Los Alamos National Laboratory (LANL), 2011 (October). ECORISK Database (Release 3.0). LA-UR-11-5460. ER ID 206473. Environmental Programs Directorate, Los Alamos National Laboratory, Los Alamos, NM.

Chemical	Chemical Abstract Service (CAS) No.	Final Ecological Screening Level	Source of Final Ecological Screening Level

MHSPE, 2000. Circular on target values and intervention values for soil remediation. Ministry of Housing, Spatial Planning and Environment. DBO/1999226863. Department of Soil Protection, The Netherlands. February 4.

Sunahara, G.I., G.R. Lotufo, R.G Kuperman, and J. Hawari, 2009. Ecotoxicology of Explosives. CRC Press, Taylor and Francis Group. 2009.

USEPA (U.S. Environmental Protection Agency), 2007. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency and Response. http://www.epa.gov/ecotox/ecossl/. (Separate documents for each chemical).

ECOLOGICAL SEDIMENT SCREENING VALUES

Chemical	Chemical Abstract Service (CAS) No.	Final Ecological Screening Level	Source of Final Ecological Screening Level
METALS (mg/kg)			
ALUMINUM	7429-90-5	25500	NOAA
ANTIMONY	7440-36-0	3	NOAA
ARSENIC	7440-38-2	9.79	TEC
BARIUM	7440-39-3	48	NOAA
BERYLLIUM	7440-41-7	NA	NA
CADMIUM	7440-43-9	0.99	TEC
CALCIUM	7440-70-2	NA	NA
CHROMIUM	7440-47-3	43.4	TEC
COBALT	7440-48-4	50	LEL
COPPER	7440-50-8	31.6	TEC
IRON	7439-89-6	20000	LEL
LEAD	7439-92-1	35.8	TEC
MERCURY	7439-97-6	0.18	TEC
MAGNESIUM	7439-95-4	NA	NA
MANGANESE	7439-96-5	460	LEL
NICKEL	7440-02-0	22.7	TEC
POTASSIUM	7440-09-7	NA	NA
SELENIUM	7782-49-2	1	NOAA
SILVER	7440-22-4	0.5	LEL
SODIUM	7440-23-5	NA	NA
THALLIUM	7440-28-0	NA	NA
VANADIUM	7440-62-2	57	NOAA
ZINC	7440-66-6	121	TEC
TCL VOCs (MG/KG)			
1,1,1-TRICHLOROETHANE	71-55-6	0.17	EPA SQB
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	76-13-1	NA	NA
1,1,2,2- TETRACHLORETHANE	79-34-5	0.94	EPA SQB
1,1,2- TRICHLOROETHANE	79-00-5	1.2	SCV
1,1- DICHLOROETHANE	75-34-3	0.027	SCV
1,1-DICHLOROETHENE	75-35-4	0.031	SCV
1,2,3-TRICHLOROBENZENE	87-61-6	NA	NA
1,2,4-TRICHLOROBENZENE	120-82-1	9.2	EPA SQB
1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	NA	NA
1,2-DIBROMOETHANE	106-93-4	NA	NA
1,2- DICHLOROBENZENE	95-50-1	0.34	EPA SQB
1,2- DICHLOROETHANE	107-06-2	0.25	SCV
1,2-DICHLOROPROPANE	78-87-5	0.333	ESV
1,3-DICHLOROBENZENE	541-73-1	1.7	EPA SQB
1,4- DICHLOROBENZENE	106-46-7	0.35	EPA SQB
1,4-DIOXANE	123-91-1	0.119	ESV
2-BUTANONE	78-93-3	0.27	SCV
2-HEXANONE	591-78-6	0.022	SCV
4-METHYL-2-PENTANONE	108-10-1	0.033	SCV
ACETONE	67-64-1	0.0087	SCV
BENZENE	71-43-2	0.057	EPA SQB
BROMODICHLOROMETHANE	75-27-4	NA	NA
BROMOCHLOROMETHANE	74-97-5	NA	NA
BROMOFORM	75-25-2	0.65	SCV
BROMOMETHANE	74-83-9	0.00137	ESV
CARBON DISULFIDE	75-15-0	0.00085	SCV
CARBON TETRACHLORIDE	56-23-5	1.2	EPA SQB
CHLOROBENZENE	108-90-7	0.82	EPA SQB
CHLOROETHANE	75-00-3	NA	NA
CHLOROFORM	67-66-3	0.022	SCV
CHLOROMETHANE	74-87-3	NA	NA
CIS-1,2- DICHLOROETHENE	156-59-2	0.4	SCV
CIS-1,3- DICHLOROPROPENE	10061-01-5	0.000051	SCV
CYCLOHEXANE	110-82-7	NA	NA
DIBROMOCHLOROMETHANE	124-48-1	NA	NA
DICHLORODIFLUOROMETHANE	75-71-8	NA	NA
ETHYLBENZENE	100-41-4	3.6	EPA SQB
ISOPROPYLBENZENE	98-82-8	NA	NA
METHYL ACETATE	79-20-9	NA	NA
METHYLCYCLOHEXANE	108-87-2	NA	NA
METHYLENE CHLORIDE	75-09-2	0.37	SCV
METHYL TERT-BUTYL ETHER	1634-04-4	NA	NA
STYRENE	100-42-5	0.254	ESV
TETRACHLOROETHENE	127-18-4	0.53	EPA SQB
TOLUENE	108-88-3	0.67	EPA SQB
TRANS-1,2- DICHLOROETHENE	156-60-5	0.4	SCV
TRANS-1,3-DICHLOROPROPENE	10061-02-6	0.000051	SCV
TRICHLOROETHENE	79-01-6	1.6	EPA SQB
TRICHLOROFLUOROMETHANE	75-69-4	NA	NA
VINYL CHLORIDE	75-01-4	0.202	ESV
O-XYLENE	95-94-6	NA	NA
m,p-XYLENE	179601-23-1	NA	NA
TCL SVOCs (MG/KG)			
1,1'-BIPHENYL	92-52-4	1.1	EPA SQB
1,2,4,5-TETRACHLOROBENZENE	95-94-3	1.252	ESV
2,2-OXYBIS(1-CHLOROPROPANE)	108-60-1	NA	NA
2,3,4,6-TETRACHLOROPHENOL	58-90-2	0.129	ESV
2,4,5-TRICHLOROPHENOL	95-95-4	0.003	NOAA
2,4,6-TRICHLOROPHENOL	88-06-2	0.006	NOAA
2,4-DICHLOROPHENOL	120-83-2	0.0002083	NOAA
2,4-DIMETHYLPHENOL	105-67-9	0.018	NOAA
2,4-DINITROPHENOL	51-28-5	0.00621	ESV
2,4-DINITROTOLUENE	121-14-2	0.0144	ESV

ECOLOGICAL SEDIMENT SCREENING VALUES

Chemical	Chemical Abstract Service (CAS) No.	Final Ecological Screening Level	Source of Final Ecological Screening Level
2,6-DINITROTOLUENE	606-20-2	0.0398	ESV
2-CHLORONAPHTHALENE	91-58-7	0.417	ESV
2-CHLOROPHENOL	95-57-8	0.000333	NOAA
2-METHYLNAPHTHALENE	91-57-6	0.064	NOAA
2-METHYLPHENOL	95-48-7	0.008	NOAA
2-NITROANILINE	88-74-4	NA	NA
2-NITROPHENOL	88-75-5	NA	NA
3,3'-DICHLOROBENZIDINE	91-94-1	0.127	ESV
3-NITROANILINE	99-09-2	NA	NA
4,6-DINITRO-2-METHYLPHENOL	534-52-1	0.104	ESV
4-BROMOPHENYL-PHENYLETHER	101-55-3	1.3	EPA SQB
4-CHLORO-3-METHYLPHENOL	59-50-7	0.388	ESV
4-CHLOROANILINE	106-47-8	0.146	ESV
4-CHLOROPHENYL-PHENYL ETHER	7005-72-3	NA	NA
4-METHYLPHENOL	106-44-5	0.1	NOAA
4-NITROANILINE	100-01-6	NA	NA
4-NITROPHENOL	100-02-7	0.0133	ESV
ACENAPHTHENE	83-32-9	0.016	EPA SQB
ACENAPHTHYLENE	208-96-8	0.00587	NOAA
ANTHRACENE	120-12-7	0.0572	TEC
ATRAZINE	1912-24-9	NA	NA
BENZALDEHYDE	100-52-7	NA	NA
BENZO (A) ANTHRACENE	56-55-3	0.108	TEC
BENZO (A) PYRENE	50-32-8	0.15	TEC
BENZO (B) FLUOROANTHENE	205-99-2	1.8	NOAA
BENZO (G,H,I) PERYLENE	191-24-2	0.17	LEL
BENZO (K) FLUOROANTHENE	207-08-9	0.24	LEL
BIS(2-CHLOROETHOXY) METHANE	111-91-1	NA	NA
BIS-(2-CHLOROETHYL) ETHER	111-44-4	3.52	ESV
BIS(2-ETHYLHEXYL) PHTHALATE	117-81-7	0.75	NOAA
BUTYLBENZYLPHTHALATE	85-68-7	11	EPA SQB
CAPROLACTAM	105-60-2	NA	NA
CARBAZOLE	86-74-8	NA	NA
CHRYSENE	218-01-9	0.166	TEC
DIBENZO (A,H)-ANTHRACENE	53-70-3	0.033	TEC
DIBENZOFURAN	132-64-9	2	EPA SQB
DIETHYLPHTHALATE	84-66-2	0.63	EPA SQB
DIMETHYLPHTHALATE	131-11-3	0.006	NOAA
DI-N-BUTYLPHTHALATE	84-74-2	11	EPA SQB
DI-N-OCTYLPHTHALATE	117-84-0	0.061	NOAA
FLUORANTHENE	206-44-0	0.423	TEC
FLUORENE	86-73-7	0.0774	TEC
HEXACHLOROBENZENE	118-74-1	0.02	NOAA
HEXACHLOROBUTADIENE	87-68-3	0.0013	NOAA
HEXACHLOROCYCLOPENTADIENE	77-47-4	0.901	ESV
HEXACHLOROETHANE	67-72-1	1	EPA SQB
INDENO (1,2,3-CD)-PYRENE	193-39-5	0.2	LEL
ISOPHORONE	78-59-1	0.432	ESV
NAPHTHALENE	91-20-3	0.176	TEC
NITROBENZENE	98-95-3	0.021	NOAA
N-NITROSO DIPHENYLAMINE	86-30-6	0.028	NOAA
N-NITROSO-DI-N PROPYLAMINE	621-64-7	NA	NA
PENTACHLOROPHENOL	87-86-5	0.017	NOAA
PHENANTHRENE	85-01-8	0.204	TEC
PHENOL	108-95-2	0.048	NOAA
PYRENE	129-00-0	0.195	TEC
EXPLOSIVES (MG/KG)			
1,3,5-TRINITROBENZENE	99-35-4	NA	NA
1,3-DINITROBENZENE	99-65-0	0.00861	ESV
2,4-DINITROTOLUENE	121-14-2	0.0144	ESV
2,6-DINITROTOLUENE	606-20-2	0.0398	ESV
NITROBENZENE	98-95-3	0.021	NOAA
2,4,6-TRINITROTOLUENE	118-96-7	NA	NA
2-AMINO-4,6-DINITROTOLUENE	35572-78-2	NA	NA
2-NITROTOLUENE	88-72-2	NA	NA
3-NITROTOLUENE	99-08-1	NA	NA
3,5-DINITROANILINE	618-87-1	NA	NA
4-AMINO-2,6-DINITROTOLUENE	1946-51-0	NA	NA
4-NITROTOLUENE	99-99-0	NA	NA
HMX	2691-41-0	NA	NA
TETRYL	479-45-8	NA	NA
RDX	121-82-4	NA	NA
PETN	78-11-5	NA	NA
NITROGLYCERIN	55-63-0	NA	NA
PCBs (MG/KG)			
AROCLOR-1016	12674-11-2	0.0598	TEC
AROCLOR-1221	11104-28-2	0.0598	TEC
AROCLOR-1232	11141-16-5	0.0598	TEC
AROCLOR-1242	53469-21-9	0.0598	TEC
AROCLOR-1248	12672-29-6	0.0598	TEC
AROCLOR-1254	11097-69-1	0.0598	TEC
AROCLOR-1260	11096-82-5	0.0598	TEC
AROCLOR-1262	37324-23-5	0.023	EPA SQB
AROCLOR-1268	11100-14-4	0.0598	TEC
TCL Pesticides (MG/KG)			

ECOLOGICAL SEDIMENT SCREENING VALUES

Chemical	Chemical Abstract Service (CAS) No.	Final Ecological Screening Level	Source of Final Ecological Screening Level
4,4'-DDD	72-54-8	0.00488	TEC
4,4'-DDE	72-55-9	0.00316	TEC
4,4'-DDT	50-29-3	0.00416	TEC
ALDRIN	309-00-2	0.002	LEL
ALPHA-BHC	319-84-6	0.006	LEL
ALPHA-CHLORDANE	5103-71-9	0.00324	TEC
BETA-BHC	319-85-7	0.005	LEL
DELTA-BHC	319-86-8	0.12	SCV
DIELDRIN	60-57-1	0.0019	TEC
ENDOSULFAN I	959-98-8	0.0029	EPA SQB
ENDOSULFAN II	33213-65-9	0.014	EPA SQB
ENDOSULFAN SULFATE	1031-07-8	0.0346	ESV
ENDRIN	72-20-8	0.00222	TEC
ENDRIN ALDEHYDE	7421-93-4	0.48	ESV
ENDRIN KETONE	53494-70-5	NA	NA
GAMMA-BHC (LINDANE)	58-89-9	0.00237	TEC
GAMMA-CHLORDANE	5103-74-2	0.00324	TEC
HEPTACHLOR	76-44-8	0.01	NOAA
HEPTACHLOR EPOXIDE	1024-57-3	0.00247	TEC
METHOXYCHLOR	72-43-5	0.019	EPA SQB
TOXAPHENE	8001-35-2	0.028	EPA SQB

Sources Selected in the Following Order of Preference:
TEC (MacDonald, et al 2000)
LEL (Persaud, et al 1993)
EPA SQB (USEPA, 1996)
NOAA (Buchman, 2008) (freshwater value selected before marine value)
SCV (Jones, et al 1997)
ESV (USEPA, 2003)
LANL (LANL, 2011)

Abbreviations:
EPA -Environmental Protection Agency
ESV - Ecological Screening Values
LANL - Los Alamos National Laboratory
LEL - Lowest Effects Level
NA - Not available
NOAA - National Oceanic and Atmospheric Administration
SCV - Secondary Chronic Values
SQB - Sediment Quality Benchmarks
TEC - Threshold Effects Concentration

References:

Buchman, M. F., 2008. NOAA Screening Quick Reference Tables, NOAA OR&R Report 08-1, Seattle, WA, Office of Response and Restoration Division, National Oceanic and Atmospheric Administration, 34 pages.

Jones, D.S., R.N. Hull, and G.W. Suter II, 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Risk Assessment Program, Health Sciences Division, Oak Ridge, Tennessee. ES/ER/TM-

Los Alamos National Laboratory (LANL), 2011 (October). ECORISK Database (Release 3.0). LA-UR-11-5460. ER ID 206473. Environmental Programs Directorate, Los Alamos National Laboratory, Los Alamos, NM.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger, 2000. "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems." Archives of Environmental Contamination and Toxicology, Vol. 39, pp. 20-31.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of Environment and Energy. August.

USEPA, 1996. ECO Update, Ecotox Thresholds. U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response. Intermittent Bulletin, Volume 3, Number 2. EPA540/F-95/038. January.

USEPA, 2003. Ecological Screening Levels. USEPA Region 5 (http://www.epa.gov/reg5rcra/ca/edql.htm). August.

APPENDIX C

LABORATORY CERTIFICATIONS AND ACCREDITATIONS

The American Association for Laboratory Accreditation

World Class Accreditation

Accredited DoD ELAP Laboratory

A2LA has accredited

ALS-MIDDLETOWN

Middletown, PA

for technical competence in the field of

Environmental Testing

In recognition of the successful completion of the A2LA evaluation process that includes an assessment of the laboratory's compliance with ISO/IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the current DoD Quality System Manual for Environmental Laboratories (QSM); accreditation is granted to this laboratory to perform recognized EPA methods as defined on the associated A2LA Environmental Scope of Accreditation. This accreditation demonstrates technical competence for this defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

Presented this 17th day of January 2012.

President & CEO
For the Accreditation Council
Certificate Number 0818.01
Valid to November 30, 2013

For the tests or types of tests to which this accreditation applies, please refer to the laboratory's Environmental Scope of Accreditation.

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005

ALS – MIDDLETOWN
34 Dogwood Lane
Middletown, PA 17057
Helen M. MacMinn Phone: 717 944 5541

ENVIRONMENTAL

Valid To: November 30, 2013 Certificate Number: 0818.01

In recognition of the successful completion of the A2LA evaluation process, (including an assessment of the laboratory's compliance with ISO IEC 17025:2005, the 2003 NELAC Chapter 5 Standard, and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the current DoD Quality Systems Manual for Environmental Laboratories) accreditation is granted to this laboratory to perform recognized EPA methods using the following testing technologies and in the analyte categories identified below:

Testing Technologies

Inductively Coupled Plasma (ICP), ICP-Mass Spectroscopy, Atomic Absorption Spectroscopy (flame), Gas Chromatography(GC), GC- Mass Spectroscopy, High Resolution Gas Chromatography/High Resolution Mass Spectroscopy, Liquid Chromatography(LC), LC- Mass Spectroscopy, Ion Chromatography, TCLP, SPLP, Spectrophotometry, Misc.- Electronic Probes

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Microwave Acid Digestion for Metals	----------	----------	--------	EPA 3015 / 3051A
Hotplate Metals Digestion	----------	----------	--------	EPA 3050
Organics Extraction - General	----------	----------	--------	EPA 3500B
Sep Funnel Liq-Liq Extraction	----------	----------	--------	EPA 3510C
Solid Phase Extraction	----------	----------	--------	EPA 3535
Microwave Organic Extraction Soils	----------	----------	--------	EPA 3546
Sonication Organic Soil Extraction	----------	----------	--------	EPA 3550
Florisil Clean-Up Organics	----------	----------	--------	EPA 3620B
Sulfur Clean-Up PCB's	----------	----------	--------	EPA 3660B
Sulfuric Acid PCBs	----------	----------	--------	EPA 3665A
VOC Soils	----------	----------	--------	EPA 5035
pH, Corrosivity, Hydrogen Ion	EPA 9040B / 9040C	EPA 9045D	--------	--------
Bromide	EPA 300.0 EPA 9056	EPA 300.0 EPA 9056	--------	--------

5301 Buckeystown Pike, Suite 350 | Frederick, Maryland 21704-8373 | Phone: 301 644 3248 | Fax: 301 662 2974 | www.A2LA.org

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Chloride	EPA 300.0 EPA 9056	EPA 300.0 EPA 9056	--------	--------
Fluoride	EPA 300.0 EPA 9056	EPA 300.0 EPA 9056	--------	--------
Nitrate	EPA 300.0 EPA 9056	EPA 300.0 EPA 9056	--------	--------
Nitrite	EPA 300.0 EPA 9056	EPA 300.0 EPA 9056	--------	--------
Sulfate	EPA 300.0 EPA 9056	EPA 300.0 EPA 9056	--------	--------
Perchlorate	EPA 314.0	----------	--------	--------
Total Organic Halides	EPA 9020B	EPA 9023	--------	--------
Aluminum	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Antimony	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Arsenic	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Barium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Beryllium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Bismuth	EPA 6010	EPA 6010	--------	--------
Boron	EPA 6010	EPA 6010	--------	--------
Cadmium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Calcium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Calcium Hardness (CaCO3)	EPA 6010	EPA 6010	--------	--------
Chromium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Cobalt	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Copper	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Hardness-Total as CaCO3	EPA 6010	EPA 6010	--------	--------
Iron	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Lead	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Lithium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Magnesium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Manganese	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Mercury	EPA 6020 EPA 7470A EPA 1631	EPA 6020 EPA 7471B	--------	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Molybdenum	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Nickel	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Potassium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Selenium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Silica as SiO2	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Silver	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Sodium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Strontium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Sulfur	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Thallium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Tin	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Titanium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Vanadium	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Zinc	EPA 6010 EPA 6020	EPA 6010 EPA 6020	--------	--------
Hexavalent Chromium	EPA 7196A	EPA 7196A	--------	--------
Ferrous Iron	SM 3500	----------	--------	--------
Ethanol	EPA 8015B	----------	--------	-------
Ethyl Acetate	EPA 8015B	----------	--------	-------
Ethylene glycol	EPA 8015B	----------	--------	--------
Isoamyl alcohol	EPA 8015B	----------	--------	--------
Isobutyl alcohol (2 methyl-1-propanol)	EPA 8015B	----------	--------	--------
Isopropyl alcohol (2-propanol) (Isopropanol)	EPA 8015B	----------	--------	--------
Methanol	EPA 8015B	----------	--------	--------
Methyl ethyl ketone (2-butanone)	EPA 8015B	----------	--------	--------
Methyl isobutyl ketone (MIBK)	EPA 8015B	----------	--------	--------
n-Butanol	EPA 8015B	----------	--------	--------
n-Propanol	EPA 8015B	----------	--------	--------
Propylene glycol	EPA 8015B	----------	--------	--------
tert-Butyl alcohol	EPA 8015B	----------	--------	--------
TPH Diesel (DRO)	EPA 8015B	EPA 8015B	--------	--------
TPH Gasoline (GRO)	EPA 8015B	----------	--------	--------
Hexane Extractable Materials (HEM)	EPA 1664	EPA 9071B	--------	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Phenolic Substances	EPA 9066	EPA 9066	--------	--------
4,4'-DDD	EPA 8081	EPA 8081	--------	--------
4,4'-DDE	EPA 8081	EPA 8081	--------	--------
4,4'-DDT	EPA 8081	EPA 8081	--------	--------
Aldrin (HHDN)	EPA 8081	EPA 8081	--------	--------
Chlordane (tech.)	EPA 8081	EPA 8081	--------	--------
Dieldrin	EPA 8081	EPA 8081	--------	--------
Endosulfan I	EPA 8081	EPA 8081	--------	--------
Endosulfan II	EPA 8081	EPA 8081	--------	--------
Endosulfan sulfate	EPA 8081	EPA 8081	--------	--------
Endrin	EPA 8081	EPA 8081	--------	--------
Endrin aldehyde	EPA 8081	EPA 8081	--------	--------
Endrin ketone	EPA 8081	EPA 8081	--------	--------
Heptachlor	EPA 8081	EPA 8081	--------	--------
Heptachlor epoxide	EPA 8081	EPA 8081	--------	--------
Methoxychlor	EPA 8081	EPA 8081	--------	--------
Mirex	EPA 8081	EPA 8081	--------	--------
Toxaphene (Chlorinated camphene)	EPA 8081	EPA 8081	--------	--------
alpha-BHC	EPA 8081	EPA 8081	--------	--------
alpha-Chlordane	EPA 8081	EPA 8081	--------	--------
beta-BHC	EPA 8081	EPA 8081	--------	--------
delta-BHC	EPA 8081	EPA 8081	--------	--------
gamma-BHC (Lindane)	EPA 8081	EPA 8081	--------	--------
gamma-Chlordane	EPA 8081	EPA 8081	--------	--------
Aroclor-1016 (PCB-1016)	EPA 8082	EPA 8082	--------	--------
Aroclor-1221 (PCB-1221)	EPA 8082	EPA 8082	--------	--------
Aroclor-1232 (PCB-1232)	EPA 8082	EPA 8082	--------	--------
Aroclor-1242 (PCB-1242)	EPA 8082	EPA 8082	--------	--------
Aroclor-1248 (PCB-1248)	EPA 8082	EPA 8082	--------	--------
Aroclor-1254 (PCB-1254)	EPA 8082	EPA 8082	--------	--------
Aroclor-1260 (PCB-1260)	EPA 8082	EPA 8082	--------	--------
Acetochlor	EPA 8141	EPA 8141	--------	--------
Alachlor	EPA 8141	EPA 8141	--------	--------
Atrazine	EPA 8141	EPA 8141	--------	--------
Azinphos Methyl	----------	EPA 8141	--------	--------
Bolstar	----------	EPA 8141	--------	--------
Bromacil	EPA 8141	EPA 8141	--------	--------
Butachlor	EPA 8141	EPA 8141	--------	--------
Chloropyrifos	EPA 8141	EPA 8141	--------	--------
Coumaphos	----------	EPA 8141	--------	--------
Cyanazine	EPA 8141	EPA 8141	--------	--------
Demeton-O	----------	EPA 8141	--------	--------
Demeton- S	----------	EPA 8141	--------	--------
Diazinon	----------	EPA 8141	--------	--------
Dichlorvos	----------	EPA 8141	--------	--------
Ethoprop	----------	EPA 8141	--------	--------
Fensulfothion	----------	EPA 8141	--------	--------
Fenthion	----------	EPA 8141	--------	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Malathion	----------	EPA 8141	--------	--------
Metolachlor	EPA 8141	EPA 8141	--------	--------
Metribuzin	EPA 8141	EPA 8141	--------	--------
Mevinphos	----------	EPA 8141	--------	--------
Molinate	EPA 8141	EPA 8141	--------	--------
Parathion Ethyl	----------	EPA 8141	--------	--------
Parathion Methyl	----------	EPA 8141	--------	--------
Pendimethalin (Penoxalin)	EPA 8141	EPA 8141	--------	--------
Phorate	----------	EPA 8141	--------	--------
Prometon	EPA 8141	EPA 8141	--------	--------
Propachlor (Ramrod)	EPA 8141	EPA 8141	--------	--------
Ronnel	----------	EPA 8141	--------	--------
Simazine	EPA 8141	EPA 8141	--------	--------
Stirophos (Tetrachlorovinphos)	----------	EPA 8141	--------	--------
Sulfotepp	----------	EPA 8141	--------	--------
Thionazin (Zinophos)	----------	EPA 8141	--------	--------
Tokuthion (Prothiophos)	----------	EPA 8141	--------	--------
Trichloronate	----------	EPA 8141	--------	--------
Trifluralin	EPA 8141	EPA 8141	--------	--------
2,4,5-T	EPA 8151	EPA 8151	--------	--------
2,4,5-TP (Silvex)	EPA 8151	EPA 8151	--------	--------
2,4-D	EPA 8151	EPA 8151	--------	--------
2,4-DB	EPA 8151	EPA 8151	--------	--------
4-Nitrophenol	----------	EPA 8151	--------	--------
Dalapon	EPA 8151	EPA 8151	--------	--------
Dicamba	EPA 8151	EPA 8151	--------	--------
Dichloroprop	EPA 8151	EPA 8151	--------	--------
Dinoseb	----------	EPA 8151	--------	--------
MCPA	----------	EPA 8151	--------	--------
MCPP	----------	EPA 8151	--------	--------
Pentachlorophenol	EPA 8151	EPA 8151	--------	--------
1,1,1,2-Tetrachloroethane	EPA 8260	EPA 8260	--------	--------
1,1,1-Trichloroethane	EPA 8260	EPA 8260	TO-15	--------
1,1,2,2-Tetrachloroethane	EPA 8260	EPA 8260	TO-15	--------
1,1,2-Trichloroethane	EPA 8260	EPA 8260	TO-15	--------
1,1,2-Trichloro-1,2,2-trifluoroethane	EPA 8260	EPA 8260	--------	--------
1,1-Dichloroethane	EPA 8260	EPA 8260	TO-15	--------
1,1-Dichloroethene (1,1-Dichloroethylene)	EPA 8260	EPA 8260	TO-15	--------
1,1-Dichloro-2-propanone	EPA 8260	EPA 8260	--------	--------
1,1-Dichloropropene	EPA 8260	EPA 8260	--------	--------
1,2,3-Trichlorobenzene	EPA 8260	EPA 8260	--------	--------
1,2,3-Trichloropropane	EPA 8260, 8011	EPA 8260	TO-15	--------
1,2,4-Trichlorobenzene	EPA 8260	EPA 8260	TO-15	--------
1,2,4-Trimethylbenzene	EPA 8260	EPA 8260	TO-15	--------
1,2-Dibromo-3-chloropropane (DBCP)	EPA 8260, 8011	EPA 8260	--------	--------
1,2-Dibromoethane (EDB)	EPA 8260, 8011	EPA 8260	TO-15	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
1,2-Dichlorobenzene	EPA 8260	EPA 8260	TO-15	--------
1,2-Dichloroethane	EPA 8260	EPA 8260	TO-15	--------
1,2-Dichloroethene	EPA 8260	EPA 8260	--------	--------
1,2-Dichloropropane	EPA 8260	EPA 8260	TO-15	--------
1,3,5-Trimethylbenzene	EPA 8260	EPA 8260	TO-15	--------
1,3-Dichlorobenzene	EPA 8260	EPA 8260	TO-15	--------
1,3-Dichloropropane	EPA 8260	EPA 8260	--------	--------
1,3-Dichloropropene	EPA 8260	EPA 8260	TO-15	--------
1,4-Dichlorobenzene	EPA 8260	EPA 8260	TO-15	--------
1,4-Dioxane (1,4-Diethyleneoxide)	EPA 8260	EPA 8260	TO-15	--------
1-Chlorobutane	EPA 8260	EPA 8260	--------	--------
1-Chlorohexane	EPA 8260	EPA 8260	--------	--------
1-Propanol	EPA 8260	EPA 8260	--------	--------
2,2-Dichloropropane	EPA 8260	EPA 8260	--------	--------
2-Butanone (MEK)	EPA 8260	EPA 8260	TO-15	--------
2-Chloroethylvinylether	EPA 8260	----------	--------	--------
2-Chlorotoluene	EPA 8260	EPA 8260	TO-15	--------
2-Hexanone (MBK)	EPA 8260	EPA 8260	TO-15	--------
2-Nitropropane	EPA 8260	EPA 8260	--------	--------
2-Propanol (isopropyl alcohol)	EPA 8260	EPA 8260	TO-15	--------
4-Chlorotoluene	EPA 8260	EPA 8260	--------	--------
4-Isopropyltoluene	EPA 8260	EPA 8260	TO-15	--------
4-Methyl-2-Pentanone (MIBK)	EPA 8260	EPA 8260	TO-15	--------
Acetone	EPA 8260	EPA 8260	TO-15	--------
Acetonitrile	EPA 8260	EPA 8260	--------	--------
Acrolein	EPA 8260	EPA 8260	--------	--------
Acrylonitrile	EPA 8260	EPA 8260	TO-15	--------
Allyl chloride (3-Chloropropene)	EPA 8260	EPA 8260	TO-15	--------
Benzene	EPA 8260	EPA 8260	TO-15	--------
Benzyl chloride	EPA 8260	EPA 8260	TO-15	--------
Bromobenzene	EPA 8260	EPA 8260	--------	--------
Bromochloromethane	EPA 8260	EPA 8260	--------	--------
Bromodichloromethane	EPA 8260	EPA 8260	TO-15	--------
Bromoform	EPA 8260	EPA 8260	TO-15	--------
Bromomethane	EPA 8260	EPA 8260	TO-15	--------
Carbon Disulfide	EPA 8260	EPA 8260	TO-15	--------
Carbon Tetrachloride	EPA 8260	EPA 8260	TO-15	--------
Chloroacetonitrile	EPA 8260	EPA 8260	--------	--------
Chlorobenzene	EPA 8260	EPA 8260	TO-15	--------
Chloroethane (ethyl chloride)	EPA 8260	EPA 8260	TO-15	--------
Chloroform	EPA 8260	EPA 8260	TO-15	--------
Chloromethane (methyl chloride)	EPA 8260	EPA 8260	TO-15	--------
Chloroprene (2-Chloro-1,3-butadiene)	EPA 8260	EPA 8260	--------	--------
Cis-1,2-Dichloroethene (cis-1,2-Dichloroethylene)	EPA 8260	EPA 8260	TO-15	--------
cis-1,3-Dichloropropene	EPA 8260	EPA 8260	TO-15	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Cyclohexane	EPA 8260	EPA 8260	TO-15	--------
Dibromochloromethane	EPA 8260	EPA 8260	TO-15	--------
Dibromomethane	EPA 8260	EPA 8260	--------	--------
Dichlorodifluoromethane	EPA 8260	EPA 8260	TO-15	--------
Dichlorofluoromethane	EPA 8260	EPA 8260	--------	--------
Diethyl Ether	EPA 8260	EPA 8260	--------	--------
Diisobutylene (2,4,4-Trimethyl-1-pentene)	EPA 8260	EPA 8260	--------	--------
Diisopropyl ether (propane)	EPA 8260	EPA 8260	TO-15	--------
Ethyl Acetate	EPA 8260	EPA 8260	TO-15	-------
Ethyl benzene	EPA 8260	EPA 8260	TO-15	--------
Ethyl methacrylate	EPA 8260	EPA 8260	--------	--------
Ethyl-t-butylether (ETBE)	EPA 8260	EPA 8260	TO-15	--------
Heptane	EPA 8260	EPA 8260	TO-15	--------
Hexachlorobutadiene	EPA 8260	EPA 8260	TO-15	--------
Hexachloroethane	EPA 8260	EPA 8260	--------	--------
Hexane	EPA 8260	EPA 8260	TO-15	--------
Iodomethane (Methyl iodide)	EPA 8260	EPA 8260	--------	--------
Isobutyl alcohol (2 methyl-1-propanol)	EPA 8260	EPA 8260	--------	--------
Isopropylbenzene (Cumene)	EPA 8260	EPA 8260	TO-15	--------
Methacrylonitrile	EPA 8260	EPA 8260	--------	--------
Methyl acetate	EPA 8260	EPA 8260	--------	--------
Methyl acrylate	EPA 8260	EPA 8260	--------	--------
Methylcyclohexane	EPA 8260	EPA 8260	--------	--------
Methylene Chloride	EPA 8260	EPA 8260	TO-15	--------
Methyl Methacrylate	EPA 8260	EPA 8260	--------	--------
Methyl-tert-butylether (MTBE)	EPA 8260	EPA 8260	TO-15	--------
m + p Xylene (1,3 +1,4 Xylene)	EPA 8260	EPA 8260	TO-15	--------
Naphthalene	EPA 8260	EPA 8260	TO-15	--------
n-Butylbenzene	EPA 8260	EPA 8260	--------	--------
Nitrobenzene	EPA 8260	EPA 8260	TO-15	--------
n-Propylbenzene	EPA 8260	EPA 8260	TO-15	--------
Octane	EPA 8260	EPA 8260	--------	--------
o-Xylene (1,2-Xylene)	EPA 8260	EPA 8260	TO-15	--------
Pentachloroethane	EPA 8260	EPA 8260	--------	--------
Pentane	EPA 8260	EPA 8260	--------	--------
Propionitrile (Ethyl cyanide)	EPA 8260	EPA 8260	--------	--------
sec-Butylbenzene	EPA 8260	EPA 8260	--------	--------
Styrene	EPA 8260	EPA 8260	TO-15	--------
T-amyl methyl ether (TAME)	EPA 8260	EPA 8260	TO-15	--------
tert-Amyl ethyl ether	EPA 8260	EPA 8260	--------	--------
tert-Amyl Alcohol (2-methyl-2-but)	EPA 8260	EPA 8260	--------	--------
tert-Butylbenzene	EPA 8260	EPA 8260	--------	--------
tert-Butyl alcohol	EPA 8260	EPA 8260	TO-15	--------
Tetrachloroethene	EPA 8260	EPA 8260	TO-15	--------
Tetrahydrofuran (THF)	EPA 8260	EPA 8260	TO-15	--------
Toluene	EPA 8260	EPA 8260	TO-15	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Trans-1,2-Dichloroethene (trans-1,2-Dichloroethylene)	EPA 8260	EPA 8260	TO-15	--------
trans 1,3-Dichloropropene	EPA 8260	EPA 8260	TO-15	--------
trans 1,4-Dichloro-2-butene	EPA 8260	EPA 8260	--------	--------
Trichloroethene (Trichloroethylene)	EPA 8260	EPA 8260	TO-15	--------
Trichlorofluoromethane	EPA 8260	EPA 8260	TO-15	--------
Vinyl Acetate	EPA 8260	EPA 8260	TO-15	--------
Vinyl Chloride	EPA 8260	EPA 8260	TO-15	--------
Xylenes-total	EPA 8260	EPA 8260	TO-15	--------
Methane, Ethane and Ethene	RSK 175	----------	--------	--------
1,2,4,5-Tetrachlorobenzene	EPA 8270	EPA 8270	--------	--------
2,3,4,6-Tetrachlorophenol	EPA 8270	EPA 8270	--------	--------
2,3,5,6-Tetrachlorophenol	EPA 8270	EPA 8270	--------	--------
1,2,4-Trichlorobenzene	EPA 8270	EPA 8270	--------	--------
1,2-Dichlorobenzene	EPA 8270	EPA 8270	--------	--------
1,2-Dinitrobenzene	EPA 8270	EPA 8270	--------	--------
1,2-Diphenylhydrazine	EPA 8270	EPA 8270	--------	--------
1,3-Dichlorobenzene	EPA 8270	EPA 8270	--------	--------
1,3-Dinitrobenzene (1,3-DNB)	EPA 8270	EPA 8270	--------	--------
1,4-Dichlorobenzene	EPA 8270	EPA 8270	--------	--------
1,4-Dinitrobenzene	EPA 8270	EPA 8270	--------	--------
1,4-Dioxane (1,4-Diethyleneoxide)	EPA 8270	EPA 8270	--------	--------
2,4,5-Trichlorophenol	EPA 8270	EPA 8270	--------	--------
2,4,6-Trichlorophenol	EPA 8270	EPA 8270	--------	--------
2,3-Dichloroaniline	EPA 8270	EPA 8270	--------	--------
2,4-Dichlorophenol	EPA 8270	EPA 8270	--------	--------
2,4-Dimethylphenol	EPA 8270	EPA 8270	--------	--------
2,4-Dinitrophenol	EPA 8270	EPA 8270	--------	--------
2,4-Dinitrotoluene (2,4-DNT)	EPA 8270	EPA 8270	--------	--------
2,6-Dichlorophenol	EPA 8270	EPA 8270	--------	--------
2,6-Dinitrotoluene (2,6-DNT)	EPA 8270	EPA 8270	--------	--------
2-Chloronaphthalene	EPA 8270	EPA 8270	--------	--------
2-Chlorophenol	EPA 8270	EPA 8270	--------	--------
2-Methylnaphthalene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
2-Methylphenol	EPA 8270	EPA 8270	--------	--------
2-Naphthylamine	EPA 8270	EPA 8270	--------	--------
2-Nitroaniline	EPA 8270	EPA 8270	--------	--------
2-Nitrophenol	EPA 8270	EPA 8270	--------	--------
3-3'-Dichlorobenzidine	EPA 8270	EPA 8270	--------	--------
3-Methylphenol	EPA 8270	EPA 8270	--------	--------
3-Nitroaniline	EPA 8270	EPA 8270	--------	--------
3&4-Methylphenol	EPA 8270	EPA 8270	--------	--------
4,6-Dinitro-2-Methylphenol (2-Methyl-4,6-dinitrophenol)	EPA 8270	EPA 8270	--------	--------
4-Bromophenyl-Phenyl Ether	EPA 8270	EPA 8270	--------	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
4-Chloroaniline	EPA 8270	EPA 8270	--------	--------
4-Chloro-3-Methylphenol	EPA 8270	EPA 8270	--------	--------
4-Chlorophenyl-Phenyl Ether	EPA 8270	EPA 8270	--------	--------
1-Methylnaphthalene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
4-Methylphenol (p-Cresol)	EPA 8270	EPA 8270	--------	--------
4-Nitroaniline	EPA 8270	EPA 8270	--------	--------
4-Nitrophenol	EPA 8270	EPA 8270	--------	--------
1,1-Biphenyl	EPA 8270	EPA 8270	--------	--------
Acenaphthene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Acenaphthylene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Acetophenone	EPA 8270	EPA 8270	--------	--------
Alpha-Terpineol	EPA 8270	EPA 8270	--------	--------
Aniline	EPA 8270	EPA 8270	--------	--------
Anthracene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Atrazine	EPA 8270	EPA 8270	--------	--------
Azobenzene	EPA 8270	EPA 8270	--------	--------
Benzidine	EPA 8270	----------	--------	--------
Benzaldehyde	EPA 8270	EPA 8270	--------	--------
Benzo(a)Anthracene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Benzo(a)Pyrene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Benzo(b)Fluoranthene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Benzo(ghi)Perylene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Benzo(k)Fluoranthene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Benzoic Acid	----------	EPA 8270	--------	--------
Benzyl alcohol	EPA 8270	EPA 8270	--------	--------
Bis(2-Chloroethyl) Ether	EPA 8270	EPA 8270	--------	--------
Bis(2-Chloroethoxy) Ether	EPA 8270	EPA 8270	--------	--------
Bis(2-Chloroethoxy) Methane	EPA 8270	EPA 8270	--------	--------
Bis(2-Chloroisopropyl) Ether	EPA 8270	EPA 8270	--------	--------
Bis(2-Ethylhexyl) Adipate	EPA 8270	EPA 8270	--------	--------
Bis(2-Ethylhexyl)Phthalate(DEHP)	EPA 8270	EPA 8270	--------	--------
Butyl benzyl phthalate	EPA 8270	EPA 8270	--------	--------
Carbazole	EPA 8270	EPA 8270	--------	--------
Caprolactam	EPA 8270	EPA 8270	--------	--------
Chrysene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Dibenzo(a,h)anthracene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Dibenzofuran	EPA 8270	EPA 8270	--------	--------
Diethyl Phthalate	EPA 8270	EPA 8270	--------	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
Dimethoate	EPA 8270	EPA 8270	--------	--------
Dimethyl Phthalate	EPA 8270	EPA 8270	--------	--------
Di-n-Butyl Phthalate	EPA 8270	EPA 8270	--------	--------
Di-n-Octyl Phthalate	EPA 8270	EPA 8270	--------	--------
Dioxin Screen (2,3,7,8-TCDD)	EPA 8270	EPA 8270	--------	--------
Diphenylamine	EPA 8270	EPA 8270	--------	--------
Fluoranthene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Fluorene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Hexachlorobenzene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	--------	--------
Hexachlorobutadiene	EPA 8270	EPA 8270	--------	--------
Hexachlorocyclopentadiene	EPA 8270	EPA 8270	--------	--------
Hexachlorethane	EPA 8270	EPA 8270	--------	--------
Indeno (1,2,3-CD) Pyrene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Isophorone	EPA 8270	EPA 8270	--------	--------
Naphthalene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Nitrobenzene	EPA 8270	EPA 8270	--------	--------
n-Decane	EPA 8270	EPA 8270	--------	--------
n-Heptadecane	EPA 8270	EPA 8270	--------	--------
n-Octadecane	EPA 8270	EPA 8270	--------	--------
n-Nitrosodiethylamine	EPA 8270	EPA 8270	--------	--------
n-Nitrosodimethylamine	EPA 8270	EPA 8270	--------	--------
n-Nitrosodiphenylamine	EPA 8270	EPA 8270	--------	--------
n-Nitroso-di-n-butylamine	EPA 8270	EPA 8270	--------	--------
n-Nitrosodi-n-Propylamine	EPA 8270	EPA 8270	--------	--------
n-Nitrosopyrrolidine	EPA 8270	EPA 8270	--------	--------
Pentachlorobenzene	EPA 8270	EPA 8270	--------	--------
Pentachlorophenol	EPA 8270	EPA 8270	--------	--------
Phenanthrene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Phenol	EPA 8270	EPA 8270	--------	--------
Pyrene	EPA 8270 EPA 8270 SIM	EPA 8270 EPA 8270 SIM	TO-13	--------
Pyridine	EPA 8270	EPA 8270	--------	--------
Resorcinol	EPA 8270	EPA 8270	--------	--------
1,3-Dinitrobenzene (1,3-DNB)	EPA 8330	EPA 8330	--------	--------
1,3,5-Trinitrobenzene (1,3,5-TNB)	EPA 8330	EPA 8330	--------	--------
2,4,6-Trinitrotoluene (2,4,6-TNT)	EPA 8330	EPA 8330	--------	--------
2,4-Dinitrotoluene (2,4-DNT)	EPA 8330	EPA 8330	--------	--------
2,6-Dinitrotoluene (2,6-DNT)	EPA 8330	EPA 8330	--------	--------
2-Amino-4,6-dinitrotoluene	EPA 8330	EPA 8330	--------	--------
3,5-Dinitroaniline	EPA 8330	EPA 8330	--------	--------
Nitrobenzene	EPA 8330	EPA 8330	--------	--------
Nitroglycerin	EPA 8330	EPA 8330	--------	--------

Parameter / Analyte	Non Potable Water	Solid Hazardous Waste Soil	Air	Associated Prep Methods
2-Nitrotoluene	EPA 8330	EPA 8330	--------	--------
3-Nitrotoluene	EPA 8330	EPA 8330	--------	--------
4-Amino-2,6-dinitrotoluene	EPA 8330	EPA 8330	--------	--------
4-Nitrotoluene	EPA 8330	EPA 8330	--------	--------
HMX	EPA 8330	EPA 8330	--------	--------
RDX	EPA 8330	EPA 8330	--------	--------
Tetryl	EPA 8330	EPA 8330	--------	--------
PETN	EPA 8330	EPA 8330	--------	--------
Total Cyanide	EPA 9012	EPA 9012	--------	--------
Reactive Cyanide	EPA 9012	EPA 9012	--------	--------
1,2,3-Trimethylbenzene	----------	----------	TO-15	--------
1,2-Dichlorotetrafluoroethane (Freon 114)	----------	----------	TO-15	--------
1,3-Hexachlorobutadiene	----------	----------	TO-15	--------
2,2,4-Trimethylpentane (Iso-octane)	----------	----------	TO-15	--------
4-Ethyltoluene	----------	----------	TO-15	--------
n-Heptane	----------	----------	TO-15	--------
n-Hexane	----------	----------	TO-15	--------
Butadiene (1,3-)	----------	----------	TO-15	--------
Propylene	----------	----------	TO-15	--------
Trichloro (1,1,2) trifluoroethane (1,2,2)	----------	----------	TO-15	--------
Vinyl Bromide	----------	----------	TO-15	--------
Xylene (m)	----------	----------	TO-15	--------
Xylene (o)	----------	----------	TO-15	--------
Xylene (p)	----------	----------	TO-15	--------
Specific Conductance	EPA 120.1 EPA 9050A	----------	--------	--------
<u>Hazardous Waste Characteristics</u>				
Toxicity Characteristic Leaching Procedure	----------	----------	--------	EPA 1311
Synthetic Precipitation Leaching Procedure	----------	----------	--------	EPA 1312

LABORATORY ACCREDITATION BUREAU

Certificate # L2223

Scope of Accreditation
For
Katahdin Analytical Services, Inc.

600 Technology Way
Scarborough, ME 04074
Leslie Dimond
207-874-2400

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.2) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Katahdin Analytical Services to perform the following tests:

Accreditation granted through: **November 4, 2012**

Testing - Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 608 / 8081B	4,4`-DDD
GC/ECD	EPA 608 / 8081B	4,4`-DDE
GC/ECD	EPA 608 / 8081B	4,4`-DDT
GC/ECD	EPA 608 / 8081B	Aldrin
GC/ECD	EPA 608 / 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Alpha-Chlordane
GC/ECD	EPA 608 / 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 608 / 8081B	Chlordane (tech.)
GC/ECD	EPA 608 / 8081B	delta-BHC
GC/ECD	EPA 608 / 8081B	Dieldrin
GC/ECD	EPA 608 / 8081B	Endosulfan I
GC/ECD	EPA 608 / 8081B	Endosulfan II
GC/ECD	EPA 608 / 8081B	Endosulfan sulfate
GC/ECD	EPA 608 / 8081B	Endrin
GC/ECD	EPA 608 / 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin Ketone
GC/ECD	EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 608 / 8081B	Heptachlor
GC/ECD	EPA 608 / 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 608 / 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 608 / 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 608 / 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 608 / 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 608 / 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 608 / 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 608 / 8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 608 / 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A MOD	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A MOD	Aroclor-1268 (PCB-1268)
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl (BZ 206)
GC/ECD	EPA 8082A	2,2',3,3',4,4',5,6-Octachlorobiphenyl (BZ 195)
GC/ECD	EPA 8082A	2,2',3,3',4,4',5-Heptachlorobiphenyl (BZ 170)
GC/ECD	EPA 8082A	2,2',3,3',4,4'-Hexachlorobiphenyl (BZ 128)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5, 5'-Heptachlorobiphenyl (BZ 180)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5', 6-Heptachlorobiphenyl (BZ 183)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5'-Hexachlorobiphenyl (BZ 138)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 6, 6'-Heptachlorobiphenyl (BZ 184)
GC/ECD	EPA 8082A	2, 2', 3, 4', 5, 5', 6-Heptachlorobiphenyl (BZ 187)
GC/ECD	EPA 8082A	2, 2', 3, 4, 5'-Pentachlorobiphenyl (BZ 87)
GC/ECD	EPA 8082A	2, 2', 3, 5'-Tetrachlorobiphenyl (BZ 44)
GC/ECD	EPA 8082A	2, 2', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 153)
GC/ECD	EPA 8082A	2, 2', 4, 5, 5'-Pentachlorobiphenyl (BZ 101)
GC/ECD	EPA 8082A	2, 2', 4', 5-Tetrachlorobiphenyl (BZ 49)
GC/ECD	EPA 8082A	2, 2', 5, 5'-Tetrachlorobiphenyl (BZ 52)
GC/ECD	EPA 8082A	2, 2', 5-Trichlorobiphenyl (BZ 18)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5-Hexachlorobiphenyl (BZ 156)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5'-Hexachlorobiphenyl (BZ 157)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4'-Pentachlorobiphenyl (BZ 105)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8082A	2, 3, 3’, 4, 4’, 5, 5’-Heptachlorobiphenyl (BZ 189)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 167)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 118)
GC/ECD	EPA 8082A	2, 3', 4, 4',5-Pentachlorobiphenyl (BZ 123)
GC/ECD	EPA 8082A	2, 3', 4, 4'-Tetrachlorobiphenyl (BZ 66)
GC/ECD	EPA 8082A	2, 3’, 4, 4’, 5-Pentachlorobiphenyl (BZ 114)
GC/ECD	EPA 8082A	2, 4, 4'-Trichlorobiphenyl (BZ 28)
GC/ECD	EPA 8082A	2, 4'-Dichlorobiphenyl (BZ 8)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 169)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 126)
GC/ECD	EPA 8082A	3, 3', 4, 4'-Tetrachlorobiphenyl (BZ 77)
GC/ECD	EPA 8082A	3, 4, 4’, 5-Tetrachlorobiphenyl (BZ 81)
GC/ECD	EPA 8082A	Decachlorobiphenyl (BZ 209)
GC/ECD	EPA 8151A	2, 4, 5-T
GC/ECD	EPA 8151A	2, 4-D
GC/ECD	EPA 8151A	2, 4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2, 4, 5-TP)
GC/FID	EPA 8015B/C MOD	Diesel range organics (DRO)
GC/FID	EPA 8015B/C MOD	Gasoline range organics (GRO)
GC/FID/PID	MA DEP VPH	Volatile Organic Hydrocarbons
GC/FID	MA DEP EPH	Extractable Petroleum Hydrocarbons
GC/FID	TNRCC Method 1005	Total Petroleum Hydrocarbons
GC/FID	FL-PRO	Petroleum Range Organics
GC/ECD	EPA 8011 / 504	1, 2-Dibromoethane (EDB)
GC/ECD	EPA 8011 / 504	1, 2-Dibromo-3-chloropropane
GC/FID	RSK-175	Methane Ethane Ethene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C / 524.2	1, 1, 1, 2-Tetrachloroethane
GC/MS	EPA 624 / 8260B,C / 524.2	1, 1, 1-Trichloroethane
GC/MS	EPA 624 / 8260B,C / 524.2	1, 1, 2, 2-Tetrachloroethane
GC/MS	EPA 8260B,C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 624 / 8260B,C / 524.2	1, 1, 2-Trichloroethane
GC/MS	EPA 624 / 8260B,C / 524.2	1, 1-Dichloroethane
GC/MS	EPA 624 / 8260B,C / 524.2	1, 1-Dichloroethene
GC/MS	EPA 8260B,C / 524.2	1, 1-Dichloropropene
GC/MS	EPA 8260B,C / 524.2	1, 2, 3-Trichlorobenzene
GC/MS	EPA 8260B,C / 524.2	1, 2, 3-Trichloropropane
GC/MS	EPA 8260B,C / 524.2	1, 2, 4-Trichlorobenzene
GC/MS	EPA 8260B,C / 524.2	1, 2, 4-Trimethylbenzene
GC/MS	EPA 8260B,C / 524.2	1, 2-Dibromo-3-chloropropane
GC/MS	EPA 8260B,C / 524.2	1, 2-Dibromoethane (EDB)
GC/MS	EPA 624 / 8260B,C / 524.2	1, 2-Dichlorobenzene
GC/MS	EPA 624 / 8260B,C / 524.2	1, 2-Dichloroethane
GC/MS	EPA 624 / 8260B,C / 524.2	1, 2-Dichloropropane
GC/MS	EPA 8260B,C / 524.2	1, 3, 5-Trimethylbenzene
GC/MS	EPA 624 / 8260B,C / 524.2	1, 3-Dichlorobenzene
GC/MS	EPA 8260B,C / 524.2	1, 3-Dichloropropane
GC/MS	EPA 624 / 8260B,C / 524.2	1, 4-Dichlorobenzene
GC/MS	EPA 8260B,C	1, 4-Dioxane
GC/MS	EPA 8260B,C / 524.2	2, 2-Dichloropropane
GC/MS	EPA 8260B,C / 524.2	2-Butanone
GC/MS	EPA 624 / 8260B,C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B,C / 524.2	2-Chlorotoluene
GC/MS	EPA 8260B,C / 524.2	2-Hexanone
GC/MS	EPA 8260B,C / 524.2	4-Chlorotoluene
GC/MS	EPA 8260B,C / 524.2	4-Methyl-2-pentanone
GC/MS	EPA 8260B,C / 524.2	Acetone
GC/MS	EPA 8260B,C	Acetonitrile
GC/MS	EPA 624 / 8260B,C	Acrolein
GC/MS	EPA 624 / 8260B,C / 524.2	Acrylonitrile

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C / 524.2	Allyl chloride
GC/MS	EPA 624 / 8260B,C / 524.2	Benzene
GC/MS	EPA 8260B,C / 524.2	Bromobenzene
GC/MS	EPA 8260B,C / 524.2	Bromochloromethane
GC/MS	EPA 624 / 8260B,C / 524.2	Bromodichloromethane
GC/MS	EPA 624 / 8260B,C / 524.2	Bromoform
GC/MS	EPA 8260B,C / 524.2	Carbon disulfide
GC/MS	EPA 624 / 8260B,C / 524.2	Carbon tetrachloride
GC/MS	EPA 624 / 8260B,C / 524.2	Chlorobenzene
GC/MS	EPA 624 / 8260B,C / 524.2	Chloroethane
GC/MS	EPA 624 / 8260B,C / 524.2	Chloroform
GC/MS	EPA 8260B,C	Chloroprene
GC/MS	EPA 8260B,C / 524.2	cis-1, 2-Dichloroethene
GC/MS	EPA 624 / 8260B,C / 524.2	cis-1, 3-Dichloropropene
GC/MS	EPA 8260B,C	Cyclohexane
GC/MS	EPA 624 / 8260B,C / 524.2	Dibromochloromethane
GC/MS	EPA 8260B,C / 524.2	Dibromomethane
GC/MS	EPA 624 / 8260B,C / 524.2	Dichlorodifluoromethane
GC/MS	EPA 8260B,C / 524.2	Diethyl ether
GC/MS	EPA 8260B,C	Di-isopropylether
GC/MS	EPA 8260B,C / 524.2	Ethyl methacrylate
GC/MS	EPA 624 / 8260B,C / 524.2	Ethylbenzene
GC/MS	EPA 8260B,C	Ethyl-t-butylether
GC/MS	EPA 8260B,C / 524.2	Hexachlorobutadiene
GC/MS	EPA 8260B,C	Iodomethane
GC/MS	EPA 8260B,C	Isobutyl alcohol
GC/MS	EPA 8260B,C / 524.2	Isopropyl benzene
GC/MS	EPA 8260B,C / 524.2	m p-xylenes
GC/MS	EPA 8260B, C	Methyl acetate
GC/MS	EPA 8260B,C / 524.2	Methacrylonitrile
GC/MS	EPA 624 / 8260B,C	Methyl bromide (Bromomethane)
GC/MS	EPA 624 / 8260B,C / 524.2	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B,C / 524.2	Methyl methacrylate

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C / 524.2	Methyl tert-butyl ether
GC/MS	EPA 8260B,C	Methylcyclohexane
GC/MS	EPA 624 / 8260B,C / 524.2	Methylene chloride
GC/MS	EPA 8260B,C / 524.2	Naphthalene
GC/MS	EPA 8260B,C / 524.2	n-Butylbenzene
GC/MS	EPA 8260B,C / 524.2	n-Propylbenzene
GC/MS	EPA 8260B,C / 524.2	o-Xylene
GC/MS	EPA 8260B,C / 524.2	p-Isopropyltoluene
GC/MS	EPA 8260B,C / 524.2	Propionitrile
GC/MS	EPA 8260B,C / 524.2	sec-butylbenzene
GC/MS	EPA 8260B,C / 524.2	Styrene
GC/MS	EPA 8260B,C	t-Amylmethylether
GC/MS	EPA 8260B,C / 524.2	tert-Butyl alcohol
GC/MS	EPA 8260B,C	tert-Butylbenzene
GC/MS	EPA 624 / 8260B,C / 524.2	Tetrachloroethene (Perchloroethylene)
GC/MS	EPA 8260B,C / 524.2	Tetrahydrofuran
GC/MS	EPA 624 / 8260B,C / 524.2	Toluene
GC/MS	EPA 624 / 8260B,C / 524.2	trans-1, 2-Dichloroethylene
GC/MS	EPA 624 / 8260B,C / 524.2	trans-1, 3-Dichloropropylene
GC/MS	EPA 8260B,C / 524.2	trans-1, 4-Dichloro-2-butuene
GC/MS	EPA 624 / 8260B,C / 524.2	Trichloroethene (Trichloroethylene)
GC/MS	EPA 624 / 8260B,C / 524.2	Trichlorofluoromethane
GC/MS	EPA 8260B,C	Vinyl acetate
GC/MS	EPA 624 / 8260B,C / 524.2	Vinyl chloride
GC/MS	EPA 624 / 8260B,C	Xylene
GC/MS	EPA 8270C,D	1, 2, 4, 5-Tetrachlorobenzene
GC/MS	EPA 625 / 8270C,D	1, 2, 4-Trichlorobenzene
GC/MS	EPA 625 / 8270C,D	1, 2-Dichlorobenzene
GC/MS	EPA 8270C,D	1, 2-Diphenylhydrazine
GC/MS	EPA 8270C,D	1, 3, 5-Trinitrobenzene
GC/MS	EPA 625 / 8270C,D	1, 3-Dichlorobenzene
GC/MS	EPA 8270C,D	1, 3-Dinitrobenzene
GC/MS	EPA 625 / 8270C,D	1, 4-Dichlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	1, 4-Dioxane
GC/MS	EPA 8270C,D	1, 4-Naphthoquinone
GC/MS	EPA 8270C,D	1, 4-Phenylenediamine
GC/MS	EPA 8270C,D	1-Methylnaphthalene
GC/MS	EPA 8270C,D	1-Naphthylamine
GC/MS	EPA 8270C,D	2, 3, 4, 6-Tetrachlorophenol
GC/MS	EPA 8270C,D	2, 4, 5-Trochlorophenol
GC/MS	EPA 625 / 8270C,D	2, 4, 6-Trichlorophenol
GC/MS	EPA 625 / 8270C,D	2, 4-Dichlorophenol
GC/MS	EPA 625 / 8270C,D	2, 4-Dimethylphenol
GC/MS	EPA 625 / 8270C,D	2, 4-Dinitrophenol
GC/MS	EPA 625 / 8270C,D	2, 4-Dinitrotoluene (2, 4-DNT)
GC/MS	EPA 8270C,D	2, 6-Dichlorophenol
GC/MS	EPA 625 / 8270C,D	2, 6-Dinitrotoluene (2, 6-DNT)
GC/MS	EPA 8270C,D	2-Acetylaminofluorene
GC/MS	EPA 625 / 8270C,D	2-Chloronaphthalene
GC/MS	EPA 625 / 8270C,D	2-Chlorophenol
GC/MS	EPA 625 / 8270C,D	2-Methyl-4 6-dinitrophenol
GC/MS	EPA 8270C,D	2-Methylnaphthalene
GC/MS	EPA 8270C,D	2-Methylphenol
GC/MS	EPA 8270C,D	2-Naphthylamine
GC/MS	EPA 8270C,D	2-Nitroaniline
GC/MS	EPA 625 / 8270C,D	2-Nitrophenol
GC/MS	EPA 8270C,D	2-Picoline
GC/MS	EPA 625 / 8270C,D	3, 3’-Dichlorobenzidine
GC/MS	EPA 8270C,D	3, 3’-Dimethylbenzidine
GC/MS	EPA 8270C,D	3-Methylcholanthrene
GC/MS	EPA 8270C,D	3-Nitroaniline
GC/MS	EPA 8270C,D	4-Aminobiphenyl
GC/MS	EPA 625 / 8270C,D	4-Bromophenyl phenyl ether
GC/MS	EPA 625 / 8270C,D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C,D	4-Chloroaniline
GC/MS	EPA 625 / 8270C,D	4-Chlorophenyl phenylether

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	4-Dimethyl aminoazobenzene
GC/MS	EPA 8270C,D	4-Methylphenol
GC/MS	EPA 8270C,D	4-Nitroaniline
GC/MS	EPA 625 / 8270C,D	4-Nitrophenol
GC/MS	EPA 8270C,D	5-Nitro-o-toluidine
GC/MS	EPA 8270C,D	7,12-Dimethylphenethylamine
GC/MS	EPA 8270C,D	a a-Dimethylphenethylamine
GC/MS	EPA 625 / 8270C,D	Acenaphthene
GC/MS	EPA 625 / 8270C,D	Acenaphthylene
GC/MS	EPA 8270C,D	Acetophenone
GC/MS	EPA 8270C,D	Aniline
GC/MS	EPA 625 / 8270C,D	Anthracene
GC/MS	EPA 8270C,D	Aramite
GC/MS	EPA 8270C,D	Atrazine
GC/MS	EPA 8270C,D	Benzaldehyde
GC/MS	EPA 625 / 8270C,D	Benzidine
GC/MS	EPA 625 / 8270C,D	Benzo(a)anthracene
GC/MS	EPA 625 / 8270C,D	Benzo(a)pyrene
GC/MS	EPA 625 / 8270C,D	Benzo(b)fluoranthene
GC/MS	EPA 625 / 8270C,D	Benzo(g h i)perylene
GC/MS	EPA 625 / 8270C,D	Benzo(k)fluoranthene
GC/MS	EPA 8270C,D	Benzoic Acid
GC/MS	EPA 8270C,D	Benzyl alcohol
GC/MS	EPA 8270C,D	Biphenyl
GC/MS	EPA 625 / 8270C,D	bis(2-Chloroethoxy)methane
GC/MS	EPA 625 / 8270C,D	bis(2-Chloroethyl) ether
GC/MS	EPA 625 / 8270C,D	bis(2-Chloroisopropyl) ether (2, 2`-Oxybis(1-chloropropane))
GC/MS	EPA 625 / 8270C,D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 625 / 8270C,D	Butyl benzyl phthalate
GC/MS	EPA 8270C,D	Caprolactam
GC/MS	EPA 8270C,D	Carbazole
GC/MS	EPA 8270C,D	Chlorobenzilate

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625 / 8270C,D	Chrysene
GC/MS	EPA 8270C,D	Diallate
GC/MS	EPA 625 / 8270C,D	Dibenz(a h)anthracene
GC/MS	EPA 8270C,D	Dibenzofuran
GC/MS	EPA 625 / 8270C,D	Diethyl phthalate
GC/MS	EPA 8270C,D	Dimethoate
GC/MS	EPA 625 / 8270C,D	Dimethyl phthalate
GC/MS	EPA 625 / 8270C,D	Di-n-butyl phthalate
GC/MS	EPA 625 / 8270C,D	Di-n-octyl phthalate
GC/MS	EPA 8270C,D	Ethyl methanesulfonate
GC/MS	EPA 8270C,D	Famfur
GC/MS	EPA 625 / 8270C,D	Fluoranthene
GC/MS	EPA 625 / 8270C,D	Fluorene
GC/MS	EPA 625 / 8270C,D	Hexachlorobenzene
GC/MS	EPA 625 / 8270C,D	Hexachlorobutadiene
GC/MS	EPA 625 / 8270C,D	Hexachlorocyclopentadiene
GC/MS	EPA 625 / 8270C,D	Hexachloroethane
GC/MS	EPA 8270C,D	Hexachloropropene
GC/MS	EPA 625 / 8270C,D	Indeno(1, 2, 3-cd)pyrene
GC/MS	EPA 8270C,D	Isodrin
GC/MS	EPA 625 / 8270C,D	Isophorone
GC/MS	EPA 8270C,D	Isosafrole
GC/MS	EPA 8270C,D	Methapyriline
GC/MS	EPA 8270C,D	Methy methanesulfonate
GC/MS	EPA 8270C,D	Methyl parathion
GC/MS	EPA 625 / 8270C,D	Naphthalene
GC/MS	EPA 625 / 8270C,D	Nitrobenzene
GC/MS	EPA 8270C,D	Nitroquinoline-1-oxide
GC/MS	EPA 8270C,D	n-Nitrosodiethylamine
GC/MS	EPA 625 / 8270C,D	n-Nitrosodimethylamine
GC/MS	EPA 8270C,D	n-Nitroso-di-n-butylamine
GC/MS	EPA 625 / 8270C,D	n-Nitrosodi-n-propylamine
GC/MS	EPA 625 / 8270C,D	n-Nitrosodiphenylamine

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	n-Nitrosomethylethylamine
GC/MS	EPA 8270C,D	n-Nitrosomorpholine
GC/MS	EPA 8270C,D	n-Nitrosopiperidine
GC/MS	EPA 8270C,D	n-Nitrosopyrrolidine
GC/MS	EPA 8270C,D	o o o-Triethyl phosphorothioate
GC/MS	EPA 8270C,D	o-Toluidine
GC/MS	EPA 8270C,D	Pentachlorobenzene
GC/MS	EPA 8270C,D	Pentachloronitrobenzene
GC/MS	EPA 625 / 8270C,D	Pentachlorophenol
GC/MS	EPA 8270C,D	Phenacetin
GC/MS	EPA 625 / 8270C,D	Phenanthrene
GC/MS	EPA 625 / 8270C,D	Phenol
GC/MS	EPA 8270C,D	Phorate
GC/MS	EPA 8270C,D	Pronamide
GC/MS	EPA 625 / 8270C,D	Pyrene
GC/MS	EPA 8270C,D	Pyrididne
GC/MS	EPA 8270C,D	Safrole
GC/MS	EPA 8270C,D	Thionazin
HPLC/UV	EPA 8330A/8330B	1, 3, 5-Trinitrobenzene
HPLC/UV	EPA 8330A/8330B	1, 3-Dinitrobenzene
HPLC/UV	EPA 8330A/8330B	2, 4, 6-Trinitrotoluene
HPLC/UV	EPA 8330A/8330B	2, 4-Dinitrotoluene
HPLC/UV	EPA 8330A/8330B	2, 6-Dinitrotoluene
HPLC/UV	EPA 8330A/8330B	2-Amino-4, 6 -Dinitrotoluene
HPLC/UV	EPA 8330A/8330B	2-Nitrotoluene
HPLC/UV	EPA 8330A/8330B	3-Nitrotoluene
HPLC/UV	EPA 8330A/8330B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/8330B	4-Amino-2,3-Dinitrotoluene
HPLC/UV	EPA 8330A/8330B	4-Nitrotoluene
HPLC/UV	EPA 8330A/8330B	Ethylene glycol dinitrate (EGDN)
HPLC/UV	EPA 8330A/8330B	Hexahydro-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)
HPLC/UV	EPA 8330A/8330B	Nitrobenzene
HPLC/UV	EPA 8330A MOD	Nitroglycerin

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC/UV	EPA 8330B	Nitroglycerin
HPLC/UV	EPA 8330A/8330B	Octahydro-1, 3, 5, 7-tetrazocine (HMX)
HPLC/UV	EPA 8330A/8330B	Pentaerythritol Tetranitrate (PETN)
HPLC/UV	EPA 8330A/8330B	Tetryl
CVAA	EPA 245.1 / 7470A	Mercury
CVAF	EPA 1631E	Low Level Mercury
ICP/AES	EPA 200.7 / 6010B,C	Aluminum
ICP/AES	EPA 200.7 / 6010B,C	Antimony
ICP/AES	EPA 200.7 / 6010B,C	Arsenic
ICP/AES	EPA 200.7 / 6010B,C	Barium
ICP/AES	EPA 200.7 / 6010B,C	Beryllium
ICP/AES	EPA 200.7 / 6010B,C	Boron
ICP/AES	EPA 200.7 / 6010B,C	Cadmium
ICP/AES	EPA 200.7 / 6010B,C	Calcium
ICP/AES	EPA 200.7 / 6010B,C	Chromium
ICP/AES	EPA 200.7 / 6010B,C	Cobalt
ICP/AES	EPA 200.7 / 6010B,C	Copper
ICP/AES	EPA 200.7 / 6010B,C	Iron
ICP/AES	EPA 200.7 / 6010B,C	Lead
ICP/AES	EPA 200.7 / 6010B,C	Magnesium
ICP/AES	EPA 200.7 / 6010B,C	Manganese
ICP/AES	EPA 200.7 / 6010B,C	Molybdenum
ICP/AES	EPA 200.7 / 6010B,C	Nickel
ICP/AES	EPA 200.7 / 6010B,C	Potassium
ICP/AES	EPA 200.7 / 6010B,C	Selenium
ICP/AES	EPA 200.7	Silicon
ICP/AES	EPA 200.7 / 6010B,C	Silver
ICP/AES	EPA 200.7 / 6010B,C	Sodium
ICP/AES	EPA 6010B,C	Strontium
ICP/AES	EPA 200.7 / 6010B,C	Thallium
ICP/AES	EPA 200.7 / 6010B,C	Tin
ICP/AES	EPA 200.7 / 6010B,C	Titanium
ICP/AES	EPA 200.7 / 6010B,C	Vanadium

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP/AES	EPA 200.7 / 6010B,C	Zinc
ICP/MS	EPA 200.8 / 6020A	Aluminum
ICP/MS	EPA 200.8 / 6020A	Antimony
ICP/MS	EPA 200.8 / 6020A	Arsenic
ICP/MS	EPA 200.8 / 6020A	Barium
ICP/MS	EPA 200.8 / 6020A	Beryllium
ICP/MS	EPA 200.8 / 6020A	Boron
ICP/MS	EPA 200.8 / 6020A	Cadmium
ICP/MS	EPA 200.8 / 6020A	Calcium
ICP/MS	EPA 200.8 / 6020A	Chromium
ICP/MS	EPA 200.8 / 6020A	Cobalt
ICP/MS	EPA 200.8 / 6020A	Copper
ICP/MS	EPA 200.8 / 6020A	Iron
ICP/MS	EPA 200.8 / 6020A	Lead
ICP/MS	EPA 200.8 / 6020A	Magnesium
ICP/MS	EPA 200.8 / 6020A	Manganese
ICP/MS	EPA 200.8 / 6020A	Molybdenum
ICP/MS	EPA 200.8 / 6020A	Nickel
ICP/MS	EPA 200.8 / 6020A	Potassium
ICP/MS	EPA 200.8 / 6020A	Selenium
ICP/MS	EPA 200.8 / 6020A	Silicon
ICP/MS	EPA 200.8 / 6020A	Silver
ICP/MS	EPA 200.8 / 6020A	Sodium
ICP/MS	EPA 6020A	Strontium
ICP/MS	EPA 200.8 / 6020A	Thallium
ICP/MS	EPA 200.8 / 6020A	Tin
ICP/MS	EPA 200.8 / 6020A	Titanium
ICP/MS	EPA 200.8 / 6020A	Tungsten
ICP/MS	EPA 200.8	Uranium
ICP/MS	EPA 200.8 / 6020A	Vanadium
ICP/MS	EPA 200.8 / 6020A	Zinc
IC	EPA 300.0 / 9056A	Bromide
IC	EPA 300.0 / 9056A	Chloride

Non-Potable Water		
Technology	**Method**	**Analyte**
IC	EPA 300.0 / 9056A	Nitrate as N
IC	EPA 300.0 / 9056A	Nitrite as N
IC	EPA 300.0 / 9056A	Nitrate + Nitrite
IC	EPA 300.0 / 9056A	Orthophosphate as P
IC	EPA 300.0 / 9056A	Sulfate
Titration	EPA 310.2 / SM 2320B	Alkalinity
Caculation	SM 2340C	Hardness
Gravimetric	EPA 1664A	Oil and Grease
Gravimetric	SM 2540B,C,D	Solids
ISE	EPA 120.1 / SM 2510B	Conductivity
ISE	SM 2520B	Practical Salinity
ISE	SM 4500F- C	Fluoride
ISE	SM 4500H+ B	pH
ISE	SM 5210B	TBOD / CBOD
Physical	EPA 1010A	Ignitability
Physical	EPA 9040C	pH
Titration	SM 2340B	Hardness
Titration	SM 4500SO_3 B	Sulfite
Titration	EPA 9034 / SM 4500S^{2-} E	Sulfide
Titration	Chap. 7.3.4	Reactive Sulfide
IR	EPA 9060A / SM 5310B	Total organic carbon
Turbidimetric	EPA 180.1 / SM 2130B	Turbidity
Turbidimetric	EPA 9038 / ASTM 516-02	Sulfate
UV/VIS	EPA 335.4 / EPA 9012B / SM 4500-CN G	Amenable cyanide
UV/VIS	EPA 350.1 / SM 4500NH3 H	Ammonia as N
UV/VIS	SM 3500Fe D	Ferrous Iron
UV/VIS	EPA 351.2	Kjeldahl nitrogen - total
UV/VIS	EPA 353.2 / SM 4500NO3 F	Nitrate + Nitrite
UV/VIS	EPA 353.2 / SM 4500NO3 F	Nitrate as N
UV/VIS	EPA 353.2 / SM 4500NO3 F	Nitrite as N
UV/VIS	EPA 365.1 / SM 4500P E	Orthophosphate as P
UV/VIS	EPA 365.4	Phosphorus total

Non-Potable Water		
Technology	**Method**	**Analyte**
UV/VIS	EPA 376.3	AVS-SEM
UV/VIS	EPA 410.4	COD
UV/VIS	EPA 420.1 / 9065	Total Phenolics
UV/VIS	SM 4500Cl G	Total Residual Chlorine
UV/VIS	SM 5540C	MBAS
UV/VIS	EPA 7196A / SM 3500-Cr D	Chromium VI
UV/VIS	EPA 9012B / 335.4	Total Cyanide
UV/VIS	EPA 9251 / SM 4500Cl E	Chloride
UV/VIS	Chap. 7.3.4	Reactive Cyanide
Preparation	**Method**	**Type**
Cleanup Methods	EPA 3640A	Gel Permeation Clean-up
Cleanup Methods	EPA 3630C	Silica Gel
Cleanup Methods	EPA 3660B	Sulfur Clean-Up
Cleanup Methods	EPA 3665A	Sulfuric Acid Clean-Up
Organic Preparation	EPA 3510C	Separatory Funnel Extraction
Organic Preparation	EPA 3520C	Continuous Liquid-Liquid Extraction
Inorganic Preparation	EPA 3010A	Hotblock
Volatile Organic Preparation	EPA 5030C	Purge and Trap

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081B	4, 4`-DDD
GC/ECD	EPA 8081B	4, 4`-DDE
GC/ECD	EPA 8081B	4, 4`-DDT
GC/ECD	EPA 8081B	Aldrin
GC/ECD	EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Alpha-Chlordane
GC/ECD	EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 608 / 8081B	Chlordane (tech.)
GC/ECD	EPA 8081B	delta-BHC
GC/ECD	EPA 8081B	Dieldrin

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081B	Endosulfan I
GC/ECD	EPA 8081B	Endosulfan II
GC/ECD	EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 8081B	Endrin
GC/ECD	EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin Ketone
GC/ECD	EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 8081B	Heptachlor
GC/ECD	EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A MOD	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A MOD	Aroclor-1268 (PCB-1268)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4', 5, 5', 6-Nonachlorobiphenyl (BZ 206)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4', 5, 6-Octachlorobiphenyl (BZ 195)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4', 5-Heptachlorobiphenyl (BZ 170)
GC/ECD	EPA 8082A	2, 2', 3, 3', 4, 4'-Hexachlorobiphenyl (BZ 128)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5, 5'-Heptachlorobiphenyl (BZ 180)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5', 6-Heptachlorobiphenyl (BZ 183)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 5'-Hexachlorobiphenyl (BZ 138)
GC/ECD	EPA 8082A	2, 2', 3, 4, 4', 6, 6'-Heptachlorobiphenyl (BZ 184)
GC/ECD	EPA 8082A	2, 2', 3, 4', 5, 5', 6-Heptachlorobiphenyl (BZ 187)
GC/ECD	EPA 8082A	2, 2', 3, 4, 5'-Pentachlorobiphenyl (BZ 87)
GC/ECD	EPA 8082A	2, 2', 3, 5'-Tetrachlorobiphenyl (BZ 44)

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8082A	2, 2', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 153)
GC/ECD	EPA 8082A	2, 2', 4, 5, 5'-Pentachlorobiphenyl (BZ 101)
GC/ECD	EPA 8082A	2, 2', 4', 5-Tetrachlorobiphenyl (BZ 49)
GC/ECD	EPA 8082A	2, 2', 5, 5'-Tetrachlorobiphenyl (BZ 52)
GC/ECD	EPA 8082A	2, 2', 5-Trichlorobiphenyl (BZ 18)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5-Hexachlorobiphenyl (BZ 156)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4', 5'-Hexachlorobiphenyl (BZ 157)
GC/ECD	EPA 8082A	2, 3, 3', 4, 4'-Pentachlorobiphenyl (BZ 105)
GC/ECD	EPA 8082A	2, 3, 3’, 4, 4’, 5, 5’-Heptachlorobiphenyl (BZ 189)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 167)
GC/ECD	EPA 8082A	2, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 118)
GC/ECD	EPA 8082A	2, 3', 4, 4',5-Pentachlorobiphenyl (BZ 123)
GC/ECD	EPA 8082A	2, 3', 4, 4'-Tetrachlorobiphenyl (BZ 66)
GC/ECD	EPA 8082A	2, 3’, 4, 4’, 5-Pentachlorobiphenyl (BZ 114)
GC/ECD	EPA 8082A	2, 4, 4'-Trichlorobiphenyl (BZ 28)
GC/ECD	EPA 8082A	2, 4'-Dichlorobiphenyl (BZ 8)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5, 5'-Hexachlorobiphenyl (BZ 169)
GC/ECD	EPA 8082A	3, 3', 4, 4', 5-Pentachlorobiphenyl (BZ 126)
GC/ECD	EPA 8082A	3, 3', 4, 4'-Tetrachlorobiphenyl (BZ 77)
GC/ECD	EPA 8082A	3, 4, 4’, 5-Tetrachlorobiphenyl (BZ 81)
GC/ECD	EPA 8082A	Decachlorobiphenyl (BZ 209)
GC/ECD	EPA 8151A	2, 4, 5-T
GC/ECD	EPA 8151A	2, 4-D
GC/ECD	EPA 8151A	2, 4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2, 4, 5-TP)
GC/FID	EPA 8015C	Diesel range organics (DRO)

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/FID	EPA 8015C	Gasoline range organics (GRO)
GC/FID/PID	MA DEP VPH	Volatile Organic Hydrocarbons
GC/FID	MA DEP EPH	Extractable Petroleum Hydrocarbons
GC/FID	TNRCC Method 1005	Total Petroleum Hydrocarbons
GC/FID	FL-PRO	Petroleum Range Organics
GC/ECD	EPA 8011	1, 2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1, 2-Dibromo-3-chloropropane
GC/MS	EPA 8260B,C	1, 1, 1, 2-Tetrachloroethane
GC/MS	EPA 8260B,C	1,1,2-Trichloro-1,2,2-trifluoroethane
GC/MS	EPA 8260B,C	1, 1, 1-Trichloroethane
GC/MS	EPA 8260B,C	1, 1, 2, 2-Tetrachloroethane
GC/MS	EPA 8260B,C	1, 1, 2-Trichloroethane
GC/MS	EPA 8260B,C	1, 1-Dichloroethane
GC/MS	EPA 8260B,C	1, 1-Dichloroethylene
GC/MS	EPA 8260B,C	1, 1-Dichloropropene
GC/MS	EPA 8260B,C	1, 2, 3-Trichlorobenzene
GC/MS	EPA 8260B,C	1, 2, 3-Trichloropropane
GC/MS	EPA 8260B,C	1, 2, 4-Trichlorobenzene
GC/MS	EPA 8260B,C	1, 2, 4-Trimethylbenzene
GC/MS	EPA 8260B,C	1, 2-Dibromo-3-chloropropane
GC/MS	EPA 8260B,C	1, 2-Dichlorobenzene
GC/MS	EPA 8260B,C	1, 2-Dichloroethane
GC/MS	EPA 8260B,C	1, 2-Dichloropropane
GC/MS	EPA 8260B,C	1, 3, 5-Trimethylbenzene
GC/MS	EPA 8260B,C	1, 3-Dichlorobenzene
GC/MS	EPA 8260B,C	1, 3-Dichloropropane
GC/MS	EPA 8260B,C	1, 4-Dichlorobenzene
GC/MS	EPA 8260B,C	1, 4-Dioxane
GC/MS	EPA 8260B,C	2, 2-Dichloropropane
GC/MS	EPA 8260B,C	2-Butanone
GC/MS	EPA 8260B,C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B,C	2-Chlorotoluene
GC/MS	EPA 8260B,C	2-Hexanone

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C	4-Chlorotoluene
GC/MS	EPA 8260B,C	4-Methyl-2-pentanone
GC/MS	EPA 8260B,C	Acetone
GC/MS	EPA 8260B,C	Acetonitrile
GC/MS	EPA 8260B,C	Acrolein
GC/MS	EPA 8260B,C	Acrylonitrile
GC/MS	EPA 8260B,C	Allyl chloride
GC/MS	EPA 8260B,C	Benzene
GC/MS	EPA 8260B,C	Bromobenzene
GC/MS	EPA 8260B,C	Bromochloromethane
GC/MS	EPA 8260B,C	Bromodichloromethane
GC/MS	EPA 8260B,C	Bromoform
GC/MS	EPA 8260B,C	Carbon disulfide
GC/MS	EPA 8260B,C	Carbon tetrachloride
GC/MS	EPA 8260B,C	Chlorobenzene
GC/MS	EPA 8260B,C	Chloroethane
GC/MS	EPA 8260B,C	Chloroform
GC/MS	EPA 8260B,C	Chloroprene
GC/MS	EPA 8260B,C	cis-1, 2-Dichloroethene
GC/MS	EPA 8260B,C	cis-1, 3-Dichloropropene
GC/MS	EPA 8260B,C	Cyclohexane
GC/MS	EPA 8260B,C	Dibromochloromethane
GC/MS	EPA 8260B,C	Dibromomethane
GC/MS	EPA 8260B,C	Dichlorodifluoromethane
GC/MS	EPA 8260B,C	Diethyl ether
GC/MS	EPA 8260B,C	Di-isopropylether
GC/MS	EPA 8260B,C	1,2-Dibromoethane (EDB)
GC/MS	EPA 8260B,C	Ethyl methacrylate
GC/MS	EPA 8260B,C	Ethylbenzene
GC/MS	EPA 8260B,C	Ethyl-t-butylether
GC/MS	EPA 8260B,C	Hexachlorobutadiene
GC/MS	EPA 8260B,C	Iodomethane
GC/MS	EPA 8260B,C	Isobutyl alcohol

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B,C	Isopropyl benzene
GC/MS	EPA 8260B, C	Methyl acetate
GC/MS	EPA 8260B,C	Methacrylonitrile
GC/MS	EPA 8260B,C	Methyl bromide (Bromomethane)
GC/MS	EPA 8260B,C	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B,C	Methyl methacrylate
GC/MS	EPA 8260B,C	Methyl tert-butyl ether
GC/MS	EPA 8260B,C	Methylcyclohexane
GC/MS	EPA 8260B,C	Methylene chloride
GC/MS	EPA 8260B,C	Naphthalene
GC/MS	EPA 8260B,C	n-Butylbenzene
GC/MS	EPA 8260B,C	n-proplybenzene
GC/MS	EPA 8260B,C	o-Xylene
GC/MS	EPA 8260B,C	p-Isopropyltoluene
GC/MS	EPA 8260B,C	Propionitrile
GC/MS	EPA 8260B,C	sec-butylbenzene
GC/MS	EPA 8260B,C	Styrene
GC/MS	EPA 8260B,C	t-Amylmethylether
GC/MS	EPA 8260B,C	tert-Butyl alcohol
GC/MS	EPA 8260B,C	tert-Butylbenzene
GC/MS	EPA 8260B,C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B,C	Tetrahydrofuran
GC/MS	EPA 8260B,C	Toluene
GC/MS	EPA 8260B,C	trans-1, 2-Dichloroethylene
GC/MS	EPA 8260B,C	trans-1, 3-Dichloropropylene
GC/MS	EPA 8260B,C	Trans-1, 4-Dichloro-2-butuene
GC/MS	EPA 8260B,C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 8260B,C	Trichlorofluoromethane
GC/MS	EPA 8260B,C	Vinyl acetate
GC/MS	EPA 8260B,C	Vinyl chloride
GC/MS	EPA 8260B,C	Xylene
GC/MS	EPA 8270C,D	1-Methylnaphthalene
GC/MS	EPA 8270C,D	1-Naphthylamine

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	2-Acetylaminofluorene
GC/MS	EPA 8270C,D	2-Chloronaphthalene
GC/MS	EPA 8270C,D	2-Chlorophenol
GC/MS	EPA 8270C,D	2-Methylnaphthalene
GC/MS	EPA 8270C,D	2-Methylphenol
GC/MS	EPA 8270C,D	2-Naphthylamine
GC/MS	EPA 8270C,D	2-Nitroaniline
GC/MS	EPA 8270C,D	2-Nitrophenol
GC/MS	EPA 8270C,D	2-Picoline
GC/MS	EPA 8270C,D	3-Methylcholanthrene
GC/MS	EPA 8270C,D	3-Nitroaniline
GC/MS	EPA 8270C,D	4-Aminobiphenyl
GC/MS	EPA 8270C,D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C,D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C,D	4-Chloroaniline
GC/MS	EPA 8270C,D	4-Chlorophenyl phenylether
GC/MS	EPA 8270C,D	4-Dimethyl aminoazobenzene
GC/MS	EPA 8270C,D	4-Methylphenol
GC/MS	EPA 8270C,D	4-Nitroaniline
GC/MS	EPA 8270C,D	4-Nitrophenol
GC/MS	EPA 8270C,D	5-Nitro-o-toluidine
GC/MS	EPA 8270C,D	a a-Dimethylphenethylamine
GC/MS	EPA 8270C,D	Acenaphthene
GC/MS	EPA 8270C,D	Acenaphthylene
GC/MS	EPA 8270C,D	Acetophenone
GC/MS	EPA 8270C,D	Aniline
GC/MS	EPA 8270C,D	Anthracene
GC/MS	EPA 8270C,D	Aramite
GC/MS	EPA 8270C,D	Atrazine
GC/MS	EPA 8270C,D	Benzaldehyde
GC/MS	EPA 8270C,D	Benzidine
GC/MS	EPA 8270C,D	Benzo(a)anthracene
GC/MS	EPA 8270C,D	Benzo(a)pyrene

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	Benzo(b)fluoranthene
GC/MS	EPA 8270C,D	Benzo(g h i)perylene
GC/MS	EPA 8270C,D	Benzo(k)fluoranthene
GC/MS	EPA 8270C,D	Benzoic Acid
GC/MS	EPA 8270C,D	Benzyl alcohol
GC/MS	EPA 8270C,D	Biphenyl
GC/MS	EPA 8270C,D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C,D	bis(2-Chloroethyl) ether
GC/MS	EPA 8270C,D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 8270C,D	Butyl benzyl phthalate
GC/MS	EPA 8270C,D	Caprolactam
GC/MS	EPA 8270C,D	Carbazole
GC/MS	EPA 8270C,D	Chlorobenzilate
GC/MS	EPA 8270C,D	Chrysene
GC/MS	EPA 8270C,D	Diallate
GC/MS	EPA 8270C,D	Dibenz(a h)anthracene
GC/MS	EPA 8270C,D	Dibenzofuran
GC/MS	EPA 8270C,D	Diethyl phthalate
GC/MS	EPA 8270C,D	Dimethoate
GC/MS	EPA 8270C,D	Dimethyl phthalate
GC/MS	EPA 8270C,D	Di-n-butyl phthalate
GC/MS	EPA 8270C,D	Di-n-octyl phthalate
GC/MS	EPA 8270C,D	Ethyl methanesulfonate
GC/MS	EPA 8270C,D	Famfur
GC/MS	EPA 8270C,D	Fluoranthene
GC/MS	EPA 8270C,D	Fluorene
GC/MS	EPA 8270C,D	Hexachlorobenzene
GC/MS	EPA 8270C,D	Hexachlorobutadiene
GC/MS	EPA 8270C,D	Hexachlorocyclopentadiene
GC/MS	EPA 8270C,D	Hexachloroethane
GC/MS	EPA 8270C,D	Hexachloropropene
GC/MS	EPA 8270C,D	Isodrin
GC/MS	EPA 8270C,D	Isophorone

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	Isosafrole
GC/MS	EPA 8270C,D	Methapyriline
GC/MS	EPA 8270C,D	Methyl methanesulfonate
GC/MS	EPA 8270C,D	Methyl parathion
GC/MS	EPA 8270C,D	Naphthalene
GC/MS	EPA 8270C,D	Nitrobenzene
GC/MS	EPA 8270C,D	Nitroquinoline-1-oxide
GC/MS	EPA 8270C,D	n-Nitrosodiethylamine
GC/MS	EPA 8270C,D	n-Nitrosodimethylamine
GC/MS	EPA 8270C,D	n-Nitroso-di-n-butylamine
GC/MS	EPA 8270C,D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270C,D	n-Nitrosodiphenylamine
GC/MS	EPA 8270C,D	n-Nitrosomethylethylamine
GC/MS	EPA 8270C,D	n-Nitrosomorpholine
GC/MS	EPA 8270C,D	n-Nitrosopiperidine
GC/MS	EPA 8270C,D	n-Nitrosopyrrolidine
GC/MS	EPA 8270C,D	o o o-Triethyl phosphorothioate
GC/MS	EPA 8270C,D	o-Toluidine
GC/MS	EPA 8270C,D	Pentachlorobenzene
GC/MS	EPA 8270C,D	Pentachloronitrobenzene
GC/MS	EPA 8270C,D	Pentachlorophenol
GC/MS	EPA 8270C,D	Phenacetin
GC/MS	EPA 8270C,D	Phenanthrene
GC/MS	EPA 8270C,D	Phenol
GC/MS	EPA 8270C,D	Phorate
GC/MS	EPA 8270C,D	Pronamide
GC/MS	EPA 8270C,D	Pyrene
GC/MS	EPA 8270C,D	Pyrididne
GC/MS	EPA 8270C,D	Safrole
GC/MS	EPA 8270C,D	Thionazin
GC/MS	EPA 8270C,D	Indeno(1, 2, 3-cd)pyrene
GC/MS	EPA 8270C,D	1, 2, 4-Trichlorobenzene
GC/MS	EPA 8270C,D	1, 3, 5-Trinitrobenzene

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C,D	1, 2, 4, 5-Tetrachlorobenzene
GC/MS	EPA 8270C,D	2, 4, 5-Trochlorophenol
GC/MS	EPA 8270C,D	2, 4, 6-Trichlorophenol
GC/MS	EPA 8270C,D	2, 3, 4, 6-Tetrachlorophenol
GC/MS	EPA 8270C,D	1, 2-Dichlorobenzene
GC/MS	EPA 8270C,D	1, 2-Diphenylhydrazine
GC/MS	EPA 8270C,D	1, 3-Dichlorobenzene
GC/MS	EPA 8270C,D	1, 3-Dinitrobenzene
GC/MS	EPA 8270C,D	1, 4-Dichlorobenzene
GC/MS	EPA 8270C,D	1, 4-Dioxane
GC/MS	EPA 8270C,D	1, 4-Naphthoquinone
GC/MS	EPA 8270C,D	1, 4-Phenylenediamine
GC/MS	EPA 8270C,D	bis(2-Chloroisopropyl) ether (2, 2`-Oxybis(1-chloropropane))
GC/MS	EPA 8270C,D	2, 4-Dichlorophenol
GC/MS	EPA 8270C,D	2, 4-Dimethylphenol
GC/MS	EPA 8270C,D	2, 4-Dinitrophenol
GC/MS	EPA 8270C,D	2, 4-Dinitrotoluene (2 4-DNT)
GC/MS	EPA 8270C,D	2, 6-Dichlorophenol
GC/MS	EPA 8270C,D	2, 6-Dinitrotoluene (2 6-DNT)
GC/MS	EPA 8270C,D	3, 3`-Dichlorobenzidine
GC/MS	EPA 8270C,D	3, 3’-Dimethylbenzidine
GC/MS	EPA 8270C,D	2-Methyl-4, 6-dinitrophenol
GC/MS	EPA 8270C,D	7,12-Dimethylphenethylamine
HPLC/UV	EPA 8330A	1 ,3, 5-Trinitrobenzene
HPLC/UV	EPA 8330A	1, 3-Dinitrobenzene
HPLC/UV	EPA 8330A	2, 4, 6-Trinitrotoluene
HPLC/UV	EPA 8330A	2, 4-Dinitrotoluene
HPLC/UV	EPA 8330A	2, 6-Dinitrotoluene
HPLC/UV	EPA 8330A	2-Amino-4, 6 -dinitrotoluene
HPLC/UV	EPA 8330A	2-Nitrotoluene
HPLC/UV	EPA 8330A	3-Nitrotoluene
HPLC/UV	EPA 8330A	3,5-Dinitroaniline

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
HPLC/UV	EPA 8330A	4-Amino-2,3-dinitrotoluene
HPLC/UV	EPA 8330A	4-Nitrotoluene
HPLC/UV	EPA 8330A	Ethylene glycol dinitrate (EGDN)
HPLC/UV	EPA 8330A	Hexahydr-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)
HPLC/UV	EPA 8330A	Nitrobenzene
HPLC/UV	EPA 8330A MOD	Nitroglycerin
HPLC/UV	EPA 8330A	Octahydro-1, 3, 5, 7-tetrazocine (HMX)
HPLC/UV	EPA 8330A	Pentaerythritol Tetranitrate (PETN)
HPLC/UV	EPA 8330A	Tetryl
HPLC/UV	8330B (W/O Soil Grinding)	1, 3, 5-Trinitrobenzene
HPLC/UV	8330B (W/O Soil Grinding)	1, 3-Dinitrobenzene
HPLC/UV	8330B (W/O Soil Grinding)	2, 4, 6-Trinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2, 4-Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2, 6-Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2-Amino-4, 6 -Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	2-Nitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	3-Nitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	3,5-Dinitroaniline
HPLC/UV	8330B (W/O Soil Grinding)	4-Amino-2,3-Dinitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	4-Nitrotoluene
HPLC/UV	8330B (W/O Soil Grinding)	Ethylene glycol dinitrate (EGDN)
HPLC/UV	8330B (W/O Soil Grinding)	Hexahydr-1, 3, 5-trinitro-1, 3, 5-triazine (RDX)
HPLC/UV	8330B (W/O Soil Grinding)	Nitrobenzene
HPLC/UV	8330B (W/O Soil Grinding)	Nitroglycerin
HPLC/UV	8330B (W/O Soil Grinding)	Octahydro-1, 3, 5, 7-tetrazocine (HMX)
HPLC/UV	8330B (W/O Soil Grinding)	Pentaerythritol Tetranitrate (PETN)
HPLC/UV	8330B (W/O Soil Grinding)	Tetryl
CVAA	EPA 7471B	Mercury
CVAF	EPA 1631E	Low Level Mercury
ICP/AES	EPA 6010B,C	Aluminum
ICP/AES	EPA 6010B,C	Antimony
ICP/AES	EPA 6010B,C	Arsenic
ICP/AES	EPA 6010B,C	Barium

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
ICP/AES	EPA 6010B,C	Beryllium
ICP/AES	EPA 6010B,C	Boron
ICP/AES	EPA 6010B,C	Cadmium
ICP/AES	EPA 6010B,C	Calcium
ICP/AES	EPA 6010B,C	Chromium
ICP/AES	EPA 6010B,C	Cobalt
ICP/AES	EPA 6010B,C	Copper
ICP/AES	EPA 6010B,C	Iron
ICP/AES	EPA 6010B,C	Lead
ICP/AES	EPA 6010B,C	Magnesium
ICP/AES	EPA 6010B,C	Manganese
ICP/AES	EPA 6010B,C	Molybdenum
ICP/AES	EPA 6010B,C	Nickel
ICP/AES	EPA 6010B,C	Potassium
ICP/AES	EPA 6010B,C	Selenium
ICP/AES	EPA 200.7	Silicon
ICP/AES	EPA 6010B,C	Silver
ICP/AES	EPA 6010B,C	Sodium
ICP/AES	EPA 6010B,C	Strontium
ICP/AES	EPA 6010B,C	Thallium
ICP/AES	EPA 6010B,C	Tin
ICP/AES	EPA 6010B,C	Titanium
ICP/AES	EPA 6010B,C	Vanadium
ICP/AES	EPA 6010B,C	Zinc
ICP/MS	EPA 6020A	Aluminum
ICP/MS	EPA 6020A	Antimony
ICP/MS	EPA 6020A	Arsenic
ICP/MS	EPA 6020A	Barium
ICP/MS	EPA 6020A	Beryllium
ICP/MS	EPA 6020A	Boron
ICP/MS	EPA 6020A	Cadmium
ICP/MS	EPA 6020A	Calcium
ICP/MS	EPA 6020A	Chromium

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
ICP/MS	EPA 6020A	Cobalt
ICP/MS	EPA 6020A	Copper
ICP/MS	EPA 6020A	Iron
ICP/MS	EPA 6020A	Lead
ICP/MS	EPA 6020A	Magnesium
ICP/MS	EPA 6020A	Manganese
ICP/MS	EPA 6020A	Molybdenum
ICP/MS	EPA 6020A	Nickel
ICP/MS	EPA 6020A	Potassium
ICP/MS	EPA 6020A	Selenium
ICP/MS	EPA 6020A	Silver
ICP/MS	EPA 6020A	Sodium
ICP/MS	EPA 6020A	Strontium
ICP/MS	EPA 6020A	Thallium
ICP/MS	EPA 6020A	Tin
ICP/MS	EPA 6020A	Titanium
ICP/MS	EPA 6020A	Tungsten
ICP/MS	EPA 6020A	Vanadium
ICP/MS	EPA 6020A	Zinc
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate as N
IC	EPA 9056A	Nitrite as N
IC	EPA 9056A	Sulfate
Gravimetric	EPA 9070A / 9071B	Oil and Grease
Physical	EPA 1010A	Ignitability
Physical	EPA 9045D	pH
Titration	Chap 7.3.4	Reactive Sulfide
IR	Lloyd Kahn	Total organic carbon
Turbidimetric	EPA 9038 / ASTM 516-02	Sulfate
UV/VIS	EPA 350.1 / SM 4500NH3 H	Ammonia as N
UV/VIS	EPA 9251 / SM 4500Cl E	Chloride
UV/VIS	Chap. 7.3.4	Reactive Cyanide

LABORATORY ACCREDITATION BUREAU

Certificate # L2223

Solid and Chemical Waste		
Technology	**Method**	**Analyte**
UV/VIS	EPA 376.3	AVS-SEM
UV/VIS	SM 3500Fe D	Ferrous Iron
Cleanup Methods	EPA 3630C	Silica Gel
UV/VIS	EPA 7196	Chromium VI
UV/VIS	EPA 7196A	Chromium VI
UV/VIS	EPA 9012B	Total cyanide
Preparation	**Method**	**Type**
Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure
Preparation	EPA 1312	Synthetic Precipitation Leaching Procedure
Cleanup Methods	EPA 3660B	Sulfur Clean-up
Cleanup Methods	EPA 3620C	Florsil Clean-up
Cleanup Methods	EPA 3630C	Silica Gel Clean-up
Cleanup Methods	EPA 3640A	GPC Clean-up
Organic Preparation	EPA 3540C	Soxhlet Extraction
Organic Preparation	EPA 3545A	Pressurized Fluid Extraction
Organic Preparation	EPA 3550C	Sonication
Inorganics Preparation	EPA 3050B	Hotblock
Inorganics Preparation	EPA 3060A	Alkaline Digestion
Volatile Organics Preparation	EPA 5035/5035A	Closed System Purge and Trap

Notes:

1) This laboratory offers commercial testing service.

Approved By: _____ Date: May 26, 2011

R. Douglas Leonard
Chief Technical Officer

Issued: 11/04/09 Revised: 01/11/10 Revised: 04/06/10 Revised: 9/9/10 Revised: 10/13/10
Revised: 1/20/11 Revised: 4/13/11 Revised: 5/26/11

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board/ACLASS
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

TestAmerica-South Burlington
30 Community Drive, Suite 11
South Burlington, VT 05403

has been assessed by ACLASS
and meets the requirements of

DoD-ELAP

while demonstrating technical competence in the field(s) of

TESTING

Refer to the accompanying Scope(s) of Accreditation for information regarding the types of tests to which this accreditation applies.

ADE-1492
Certificate Number

ACLASS Approval
Certificate Valid: 10/22/2010 – 10/22/2012
Version No. 002

SCOPE OF DoD-ELAP ACCREDITATION

TestAmerica – South Burlington

30 Community Drive, Suite 11, South Burlington, VT 05403
Kirsten McCracken Phone: 802-660-1990

TESTING

Valid to: October 22, 2012 Certificate Number: ADE - 1492

I. Environmental

MATRIX	SPECIFIC TEST or ANALYTE GROUP	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Water	Acid Digestion for Metals	3005A	
Water	Acid Digestion for Metals	3010A	
Solids	Acid digestion	3050; 3050B	
Water	Separatory Funnel Extraction	3510C	
Solids	Soxhlet extraction	3540C	
Solids	Ultrasonic Extraction	3550B	
Water/Solids	Florisil Cleanup	3620C	
Water/Solids	Silica Gel Cleanup	3630	
Water/Solids	Sulfuric Acid/ Permanganate Cleanup	3665A	
Water/Solids	GPC Cleanup	3640A	
Water	Purge and Trap	5030B	
Solids	Purge and Trap	5035	

MATRIX	SPECIFIC TEST or ANALYTE GROUP	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Water	Perchlorate	6850	HPLC/MS
Water	Perchlorate	331.0	HPLC
Solids	pH	9045	pH Meter
Water	pH	9040B	pH Meter
Water	TOC	9060	Catalytic Combustion and Infrared Detector
Solids	TOC	Lloyd Kahn	Elemental Analyzer (Differential TCD)
Water	Cyanide	9012A	Automated Colorimetric
Solids	Extraction Procedure for Cyanide Analysis	9013	
Solids	Cyanide	9012B	Automated Colorimetric
Water	Mercury	7470A	CVAA
Solids	Mercury	7471A	CVAA
Water / Solids	Metals	6010B	ICP-OES
Water / Solids	Metals	6020	ICP-MS
Water / Solids	PCBs	8082	GC/ECD
Water / Solids	Pesticides	8081	GC/ECD
Water / Solids	Herbicides	8151A	GC/ECD
Water / Solids	Semivolatile Organic Compounds	8270C	GC/MS
Water / Solids	Volatile Organic Compounds	8260B	GC/MS
Air	Volatile Organic Compounds	TO15	GC/MS

500 Montgomery St. Suite 625 | Alexandria, VA 22314 | 703-836-0025 | www.aclasscorp.com

MATRIX	SPECIFIC TEST or ANALYTE GROUP	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY USED
Solids	Diesel Range Organics	8015B	GC/FID

Notes:

1. ** = As Applicable*
2. *This scope is part of and must be included with the Certificate of Accreditation No. ADE-1492*

Vice President

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Accredited Analytes/Methods (by matrix)

TestAmerica Laboratories, Inc

South Burlington, VT

NELAC Code	Analyte	Matrix					
		Aqueous		Solid		Air	
	Trace Metals						
1000	Aluminum	6010B	6020	6010B	6020		
1005	Antimony	6010B	6020	6010B			
1010	Arsenic	6010B	6020	6010B	6020		
1015	Barium	6010B	6020	6010B	6020		
1020	Beryllium	6010B	6020	6010B	6020		
1025	Boron	6010B	6020	6010B	6020		
1030	Cadmium	6010B	6020	6010B	6020		
1035	Calcium	6010B	6020	6010B			
1040	Chromium, total	6010B	6020	6010B	6020		
1045	Chromium VI	6010B		6010B			
	Cobalt	6010B	6020	6010B	6020		
1055	Copper	6010B	6020	6010B	6020		
1070	Iron	6010B	6020	6010B	6020		
1075	Lead	6010B	6020	6010B	6020		
1085	Magnesium	6010B		6010B			
1090	Manganese	6010B	6020	6010B	6020		
1095	Mercury	7470A		7471			
1100	Molybdenum	6010B	6020	6010B	6020		
1105	Nickel	6010B	6020	6010B	6020		
1125	Potassium	6010B	6020	6010B	6020		
1140	Selenium	6010B	6020	6010B	6020		
1150	Silver	6010B	6020	6010B			
	Sodium	6010B	6020	6010B	6020		
1165	Strontium	6010B		6010B			
1165	Thallium	6010B	6020	6010B			
1180	Tin	6010B		6010B			
1185	Titanium	6010B		6010B			
1185	Vanadium	6010B	6020	6010B	6020		
1190	Zinc	6010B	6020	6010B	6020		
	Misc Analytes						
1895	Perchlorate	331.0	6850				
1900	pH	9040		9045			
1645	Total Cyanide	9012		9012			
	VOCs						
4315	Acetone	8260B		8260B			
4325	Acrolein	8260B		8260B			
4340	Acrylonitrile	8260B					
4375	Benzene	8260B		8260B		TO-15	
4385	Bromobenzene	8260B		8260B			
4390	Bromochloromethane	8260B					
4395	Bromodichloromethane	8260B		8260B		TO-15	
4400	Bromoform	8260B		8260B		TO-15	
4950	Bromomethane	8260B		8260B		TO-15	
4410	2-Butanone (MEK)			8260B		TO-15	
4445	tert-Butylbenzene	8260B					
4450	Carbon disulfide	8260B		8260B			
4455	Carbon Tetrachloride	8260B		8260B		TO-15	
4475	Chlorobenzene	8260B		8260B		TO-15	
4575	Chlorodibromomethane	8260B		8260B		TO-15	
4485	Chloroethane			8260B		TO-15	

Accredited Analytes/Methods (by matrix)

TestAmerica Laboratories, Inc

South Burlington, VT

NELAC Code	Analyte	Matrix					
		Aqueous		Solid		Air	
4500	2-Chloroethylvinylether	8260B		8260B			
4505	Chloroform	8260B		8260B		TO-15	
4960	Chloromethane	8260B		8260B		TO-15	
4555	Cyclohexane					TO-15	
4570	1,2-Dibromo-3-chloropropane (DBCP)	8260B		8260B			
4585	1,2-Dibromoethane (EDB)	8260B		8260B		TO-15	
4595	Dibromomethane	8260B		8260B			
4610	1,2-Dichlorobenzene	8260B		8260B		TO-15	
4615	1,3-Dichlorobenzene	8260B		8260B			
4620	1,4-Dichlorobenzene	8260B		8260B		TO-15	
4625	Dichlorodifluoromethane	8260B		8260B		TO-15	
4630	1,1-Dichloroethane	8260B		8260B		TO-15	
4635	1,2-Dichloroethane	8260B		8260B		TO-15	
4640	1,1-Dichloroethene	8260B		8260B		TO-15	
4645	*cis*-1,2-Dichloroethene	8260B		8260B		TO-15	
4700	trans-1,2-Dichloroethene	8260B		8260B			
4975	Dichloromethane (Methylene Chloride)	8260B		8260B			
4655	1,2-Dichloropropane	8260B		8260B		TO-15	
4660	1,3-Dichloropropane			8260B			
4665	2,2-Dichloropropane			8260B			
4670	1,1-Dichloropropene			8260B			
4680	cis-1,3-Dichloropropene	8260B		8260B			
4685	*trans*-1,3-Dichloropropene	8260B				TO-15	
4695	1,2 Dichlorotetrafluoroethane (Freon 114)					TO-15	
9375	Di-isopropylether (DIPE)						
4765	Ethylbenzene	8260B		8260B		TO-15	
4768	p-Ethyltoluene					TO-15	
4825	n-Heptane					TO-15	
4835	Hexachlorobutadiene	8260B		8260B		TO-15	
4825	n-Heptane					TO-15	
4855	n-Hexane					TO-15	
4860	2-Hexanone	8260B		8260B			
4900	Isopropylbenzene			8260B			
4910	4-Isopropyltoluene			8260B			
4995	4-Methyl-2-pentanone (MIBK)	8260B		8260B		TO-15	
5000	Methyl-tert-butylether (MTBE)	8260B		8260B		TO-15	
5005	Naphthalene	8260B		8260B			
5090	n-Propylbenzene	8260B		8260B			
5100	Styrene	8260B		8260B			
4370	tert-amylmethylether (TAME)						
5105	1,1,1,2-Tetrachloroethane	8260B		8260B			
5110	1,1,2,2-Tetrachloroethane	8260B		8260B		TO-15	
5115	Tetrachloroethene	8260B		8260B		TO-15	
5140	Toluene					TO-15	
5150	1,2,3-Trichlorobenzene			8260B			
5155	1,2,4-Trichlorobenzene	8260B		8260B			
5160	1,1,1-Trichloroethane	8260B		8260B			
5165	1,1,2-Trichloroethane	8260B		8260B			
5170	Trichloroethene	8260B		8260B			
5160	1,1,1-Trichloroethane					TO-15	
5165	1,1,2-Trichloroethane					TO-15	
5170	Trichloroethene					TO-15	
5175	Trichlorofluoromethane (Freon 11)					TO-15	
5180	1,2,3-Trichloropropane	8260B		8260B			
5195	Trichlorotrifluoromethane (Freon 113)					TO-15	
5210	1,2,4-Trimethylbenzene					TO-15	
5215	1,3,5-Trimethylbenzene					TO-15	

Accredited Analytes/Methods (by matrix)

TestAmerica Laboratories, Inc

South Burlington, VT

NELAC Code	Analyte	Matrix					
		Aqueous		Solid		Air	
5225	Vinyl acetate	8260B		8260B			
5230	Vinyl bromide						
5235	Vinyl chloride	8260B		8260B		TO-15	
5260	Xylenes, total	8260B		8260B		TO-15	
	SVOCs - Base/Neutrals/Acids						
5500	Acenaphthene	8270C		8270C	8270SIM		
5505	Acenaphthylene	8270C		8270C	8270SIM		
5545	Aniline	8270C		8270C			
5555	Anthracene	8270C		8270C	8270SIM		
5575	Benzo(a)anthracene	8270C		8270C	8270SIM		
5585	Benzo(b)fluoranthene	8270C		8270C	8270SIM		
5600	Benzo(k)fluoranthene	8270C		8270C	8270SIM		
5590	Benzo(g,h,i)perylene	8270C		8270C	8270SIM		
5580	Benzo(a)pyrene	8270C		8270C	8270SIM		
5595	Benzidine	8270C		8270C			
5610	Benzoic acid	8270C		8270C			
5630	Benzyl alcohol	8270C		8270C			
5660	4-Bromophenyl-phenylether	8270C		8270C			
5670	Butyl benzyl phthalate	8270C					
5680	Carbazole	8270C					
5745	4-Chloroaniline	8270C					
5760	bis(2-Chloroethoxy)methane	8270C		8270C			
5765	bis(2-Chloroethyl)ether	8270C		8270C			
5780	bis(2-Chloroiospropyl) ether	8270C		8270C			
5700	4-Chloro-3-methylphenol	8270C					
5790	1-Chloronaphthalene	8270C					
5795	2-Chloronaphthalene	8270C		8270C			
5825	4-Chlorophenyl-phenylether	8270C		8270C			
5800	2-Chlorophenol	8270C					
5855	Chrysene	8270C		8270C	8270SIM		
5895	Dibenzo(a,h)anthracene	8270C		8270C	8270SIM		
5905	Dibenzofuran	8270C		8270C			
5925	Di-n-butylphthalate	8270C		8270C			
4610	1,2-Dichlorobenzene	8270C		8270C			
4615	1,3-Dichlorobenzene	8270C		8270C			
4620	1,4-Dichlorobenzene	8270C		8270C			
5945	3,3'-Dichlorobenzidine	8270C		8270C			
6000	2,4-Dichlorophenol	8270C		8270C			
6005	2,6-Dichlorophenol	8270C		8270C			
6070	Diethyl phthalate	8270C		8270C			
6130	2,4-Dimethylphenol	8270C		8270C			
6135	Dimethylphthalate	8270C		8270C			
6175	2,4-Dinitrophenol	8270C		8270C			
6185	2,4-Dinitrotoluene	8270C		8270C			
6190	2,6-Dinitrotoluene	8270C					
6200	Di-n-octylphthalate	8270C		8270C			
4740	p-Dioxane	8270C					
6255	bis(2-ethylhexyl) phthalate	8270C		8270C			
6265	Fluoranthene	8270C		8270C	8270SIM		
6270	Fluorene	8270C		8270C	8270SIM		
6275	Hexachlorobenzene	8270C		8270C			
4835	Hexachlorobutadiene	8270C		8270C			
6285	Hexachlorocyclopentadiene	8270C		8270C			
4840	Hexachloroethane	8270C		8270C			
6315	Indeno(1,2,3, cd)pyrene	8270C		8270C	8270SIM		
6320	Isophorone	8270C		8270C			

Accredited Analytes/Methods (by matrix)

TestAmerica Laboratories, Inc

South Burlington, VT

NELAC Code	Analyte	Matrix					
		Aqueous		Solid		Air	
6360	2-Methyl-4,6-Dinitrophenol	8270C		8270C			
6400	2-Methylphenol	8270C		8270C			
6410	4-Methylphenol (and/or 3-Methylphenol)	8270C		8270C			
6380	1-Methylnaphthalene	8270C					
6385	2-Methylnaphthalene	8270C		8270C			
5005	Naphthalene	8270C		8270C	8270SIM		
6460	2-Nitroaniline	8270C		8270C			
6465	3-Nitroaniline	8270C		8270C			
6470	4-Nitroaniline	8270C		8270C			
5015	Nitrobenzene	8270C					
6490	2-Nitrophenol	8270C					
6495	3-Nitrophenol	8270C					
6500	4-Nitrophenol	8270C					
6525	N-Nitrosodiethylamine	8270C		8270C			
6530	N-Nitrosodimethylamine	8270C		8270C			
6535	N-Nitrosodiphenylamine	8270C		8270C			
6545	N-Nitroso-di-n-propylamine	8270C		8270C			
6590	Pentachlorobenzene	8270C		8270C			
6605	Pentachlorophenol	8270C		8270C			
6615	Phenanthrene	8270C		8270C	8270SIM		
6625	Phenol	8270C		8270C			
6665	Pyrene	8270C		8270C	8270SIM		
5095	Pyridine	8270C		8270C			
6715	1,2,4,5-Tetrachlorobenzene	8270C		8270C			
6735	2,3,4,6-Tetrachlorophenol	8270C					
5145	o-Toluidine	8270C					
5155	1,2,4-Trichlorobenzene	8270C					
6835	2,4,5-Trichlorophenol	8270C		8270C			
6840	2,4,6-Trichlorophenol	8270C					
6530	N-Nitrosodimethylamine						
	PCBs						
8880	Aroclor 1016	8082		8082			
8885	Aroclor 1221	8082		8082			
8890	Aroclor 1232	8082		8082			
8895	Aroclor 1242	8082		8082			
8900	Aroclor 1248	8082		8082			
8905	Aroclor 1254	8082		8082			
8910	Aroclor 1260	8082		8082			
	Herbicides						
8655	2,4,5-T	8151A		8151A			
8650	2,4,5-TP (Silvex)	8151A		8151A			
8545	2,4-D	8151A		8151A			
8560	2,4-DB	8151A		8151A			
8600	3,5-Dichlorobenzoic acid	8151A		8151A			
8555	Dalapon	8151A		8151A			
8595	Dicamba	8151A		8151A			
8605	Dichloroprop	8151A		8151A			
8620	Dinoseb	8151A		8151A			
	MCPA	8151A					
	MCPP	8151A					
9411	Glyphosate	8151A		8151A			
9528	Paraquat	8151A		8151A			
6605	Pentachlorophenol	8151A		8151A			

Accredited Analytes/Methods (by matrix)

TestAmerica Laboratories, Inc

South Burlington, VT

NELAC Code	Analyte	Matrix					
		Aqueous		Solid		Air	
	Pesticides						
7025	Aldrin	8081A		8081A			
7065	Atrazine	8081A					
7075	Azinphos-methyl (Guthion)	8081A					
7110	alpha-BHC	8081A		8081A			
7115	beta-BHC	8081A		8081A			
7105	delta-BHC	8081A		8081A			
7120	gamma-BHC (Lindane)	8081A		8081A			
7130	Bromacil	8081A					
7160	Butachlor	8081A					
7240	alpha-Chlordane	8081A					
7245	gamma-Chlordane	8081A		8081A			
7250	Chlordane (technical)	8081A					
7355	DDD (4,4)	8081A		8081A			
7360	DDE (4,4)	8081A		8081A			
7365	DDT (4,4)	8081A		8081A			
7410	Diazinon	8081A					
7470	Dieldrin	8081A		8081A			
7510	Endosulfan I	8081A		8081A			
7515	Endosulfan II	8081A		8081A			
7520	Endosulfan sulfate	8081A		8081A			
7540	Endrin	8081A		8081A			
7530	Endrin aldehyde	8081A		8081A			
7535	Endrin ketone	8081A		8081A			
7685	Heptachlor	8081A		8081A			
7690	Heptachlor Epoxide (beta)	8081A		8081A			
6275	Hexachlorobenzene	8081A					
6285	Hexachlorocyclopentadiene	8081A					
7120	Lindane	8081A					
7770	Malathion	8081A					
7810	Methoxychlor	8081A		8081A			
7835	Metolachlor	8081A					
7845	Metribuzin	8081A					
7875	Molinate (Ordram)	8081A					
7955	Parathion, ethyl	8081A					
8045	Propachlor	8081A					
8125	Simazine	8081A					
8250	Toxaphene (total)	8081A		8081A			
8295	Trifluralin	8081A					

Target List	EPA Method	Soil LOQ	Soil LODs	Soil MDLs		Water LOQ	Water LODs	Water MDLs	
MA DEP EPH		**mg/Kg**	**mg/Kg**	**mg/Kg**		**ug/L**	**ug/L**	**ug/L**	
Total EPH C9-C18	EPH	20	15	10		100	75	50	
Total EPH C19-C36	EPH	20	15	10		100	75	50	
Total EPH C11-C22	EPH	20	15	10		100	75	50	
Naphthalene	EPH	0.2	0.15	0.13		2	1.5	0.9	
2-Methylnaphthalene	EPH	0.2	0.15	0.12		2	1.5	0.8	
Acenaphthylene	EPH	0.2	0.15	0.10		2	1.5	0.8	
Acenaphthene	EPH	0.2	0.19	0.17		2	1.9	1.8	
Fluorene	EPH	0.2	0.15	0.068		2	1.5	0.9	
Phenanthrene	EPH	0.2	0.15	0.080		2	1.5	0.9	
Anthracene	EPH	0.2	0.15	0.12		2	1.5	1.4	
Fluoranthene	EPH	0.2	0.15	0.085		2	1.5	0.8	
Pyrene	EPH	0.2	0.15	0.085		2	1.5	1.1	
Benzo(a)anthracene	EPH	0.2	0.15	0.12		2	1.5	1.4	
Chrysene	EPH	0.2	0.15	0.11		2	1.5	0.9	
Benzo(b)fluoranthene	EPH	0.2	0.15	0.088		2	1.5	0.8	
Benzo(k)fluoranthene	EPH	0.2	0.15	0.11		2	1.5	1.0	
Benzo(a)pyrene	EPH	0.2	0.15	0.10		2	1.5	1.3	
Inden(1,2,3-cd)pyrene	EPH	0.2	0.15	0.082		2	1.5	1.4	
Dibenz(a,h)anthracene	EPH	0.2	0.15	0.10		2	1.5	1.2	
Benzo(g,h,I)perylene	EPH	0.2	0.15	0.12		2	1.5	1.3	
MA DEP VPH		**mg/Kg**	**mg/Kg**	**mg/Kg**		**ug/L**	**ug/L**	**ug/L**	
Total VPH C5-C8	VPH	25	19	12.5		100	75	50.0	
Total VPH C9-C12	VPH	25	19	12.50		100	75	50	
Total VPH C9-C10	VPH	25	19	12.5		100	75	50	
Methyl-tert-butylether	VPH	1.25	0.94	0.028		5	3.8	0.31	
Benzene	VPH	1.25	0.94	0.024		5	3.8	0.33	
Toluene	VPH	1.25	0.94	0.044		5	3.8	0.79	
Ethylbenzene	VPH	1.25	0.94	0.055		5	3.8	0.67	
m,p-Xylenes	VPH	2.5	1.9	0.14		10	7.5	1.7	
o-Xylene	VPH	1.25	0.94	0.044		5	3.8	0.18	
Naphthalene	VPH	1.25	0.94	0.066		5	3.8	1.5	

Target List	EPA Method	Soil LOQ	Soil LODs	Soil MDLs	DOD Limits Lower	DOD Limits High
Volatile Organic Compounds		**ug/Kg**	**ug/Kg**	**ug/Kg**	**Soil**	**Soil**
1,1,1-Trichloroethane	8260B	5.0	2.5	0.42	70	135
1,1,2,2-Tetrachloroethane	8260B	5.0	2.5	0.84	55	130
1,1,2-Trichloro-1,2,2-triflurorethane	8260B	5.0	2.5	0.90	67	135
1,1,2-Trichloroethane	8260B	5.0	2.5	0.97	60	125
1,1-Dichloroethane	8260B	5.0	2.5	1.7	75	125
1,1-Dichloroethene	8260B	5.0	2.5	0.93	65	135
1,2,3-Trichlorobenzene	8260B	5.0	2.5	0.76	60	135
1,2,4-Trichlorobenzene	8260B	5.0	2.5	0.79	65	130
1,2-Dibromo-3-Chloropropane	8260B	5.0	2.5	1.50	40	135
1,2-Dibromoethane	8260B	5.0	2.5	1.2	70	125
1,2-Dichlorobenzene	8260B	5.0	2.5	0.78	75	120
1,2-Dichloroethane	8260B	5.0	2.5	1.0	70	135
1,2-Dichloropropane	8260B	5.0	2.5	1.4	70	120
1,3-Dichlorobenzene	8260B	5.0	2.5	0.62	70	125
1,4-Dichlorobenzene	8260B	5.0	2.5	0.44	70	125
2-Butanone (MEK)	8260B	25	12.5	5.9	30	160
2-Hexanone	8260B	25	12.5	4.8	45	145
4-methyl-2-pentanone	8260B	25.0	12.5	5.9	45	145
Acetone	8260B	25	12.5	5.1	20	160
Benzene	8260B	5.0	2.5	0.92	75	125
Bromochloromethane	8260B	5.0	2.5	0.91	70	125
Bromodichloromethane	8260B	5.0	2.5	0.60	70	130
Bromoform	8260B	5.0	2.5	0.70	55	135
Bromomethane	8260B	10	5	1.1	30	160
Carbon Disulfide	8260B	5.0	2.5	0.78	45	160
Carbon Tetrachloride	8260B	5.0	2.5	1.3	65	135
Chlorobenzene	8260B	5.0	2.5	0.51	75	125
Chloroethane	8260B	10	5	1.3	40	155
Chloroform	8260B	5.0	2.5	0.35	70	125
Chloromethane	8260B	10	5	1.4	50	130
cis-1,2-Dichloroethene	8260B	5.0	2.5	0.91	65	125
cis-1,3-Dichloropropene	8260B	5.0	2.5	0.72	70	125
Cyclohexane	8260B	5.0	2.5	1.4	75	128
Dibromochloromethane	8260B	5.0	2.5	1.0	65	130
Dichlorodifluoromethane	8260B	10	5	0.92	35	135
Ethylbenzene	8260B	5.0	2.5	0.65	75	125
Isopropylbenzene	8260B	5.0	2.5	0.92	75	130

Target List	EPA Method	Soil LOQ	Soil LODs	Soil MDLs	DOD Limits Lower	DOD Limits High
m+p-Xylene	8260B	10	5	1.7	80	125
Methyl Acetate	8260B	5.0	3	2.7	72	133
Methyl tert-butyl ether	8260B	5.0	2.5	1.1	81	125
Methylcyclohexane	8260B	5.0	2.5	0.96	71	127
Methylene Chloride	8260B	25	12.5	7.9	55	140
o-Xylene	8260B	5.0	2.5	1.3	75	125
Styrene	8260B	5.0	2.5	0.51	75	125
Tetrachloroethene	8260B	5.0	2.5	1.2	65	140
Toluene	8260B	5.0	2.5	1.4	70	125
trans-1,2-Dichloroethene	8260B	5.0	2.5	0.71	65	135
trans-1,3-Dichloropropene	8260B	5.0	2.5	0.86	65	125
Trichloroethene	8260B	5.0	2.5	0.59	75	125
Trichlorofluoromethane	8260B	10	5	0.91	25	185
Vinyl Chloride	8260B	10	5	0.87	60	125
Xylenes (Total)	8260B	15	7.5	1.3	81	114
Surrogates:						
DBFM	8260B	--	--	--	64	130
1,2-DCA-d4	8260B	--	--	--	58	134
Toluene-d8	8260B	--	--	--	85	120
BFB	8260B	--	--	--	85	120
Semivolatile Organic Compounds		**ug/Kg**	**ug/Kg**	**ug/Kg**		
1,1'-Biphenyl	8270C/D	330	248	73	50	113
1,2,4,5-Tetrachlorobenzene	8270C/D	330	248	135	30	150
2,2'-Oxybis(1-chloropropane	8270C/D	330	248	89	20	115
2,3,4,6-Tetrachlorophenol	8270C/D	330	248	140	58	93
2,4,5-trichlorophenol	8270C/D	820	615	155	50	110
2,4,6-Trichlorophenol	8270C/D	330	248	155	45	110
2,4-Dichlorophenol	8270C/D	330	248	150	45	110
2,4-Dimethylphenol	8270C/D	330	248	165	30	105
2,4-Dinitrophenol	8270C/D	820	615	377	15	130
2,4-Dinitrotoluene	8270C/D	330	248	85	50	115
2,6-Dinitrotoluene	8270C/D	330	248	79	50	110
2-Chloronaphthalene	8270C/D	330	248	87	45	105
2-Chlorophenol	8270C/D	330	248	164	45	105
2-Methylphenol	8270C/D	330	248	200	40	105
2-Nitroaniline	8270C/D	820	615	75	45	120
2-Nitrophenol	8270C/D	330	248	167	10	110
3&4-Methylphenol	8270C/D	330	248	187	40	105

Target List	EPA Method	Soil LOQ	Soil LODs	Soil MDLs	DOD Limits Lower	DOD Limits High
3,3'-Dichlorobenzidine	8270C/D	330	248	114	10	130
3-Nitroaniline	8270C/D	820	615	94	25	110
4,6-Dinitro-2-methylphenol	8270C/D	820	615	337	30	135
4-Bromophenyl-phenylether	8270C/D	330	248	85	45	115
4-Chloro-3-methylphenol	8270C/D	330	248	166	45	115
4-Chloroaniline	8270C/D	330	248	119	10	100
4-Chlorophenyl-phenylether	8270C/D	330	248	78	45	110
4-Nitroaniline	8270C/D	820	615	134	35	115
4-Nitrophenol	8270C/D	820	615	309	15	140
Atrazine	8270C/D	330	248	91	55	135
Benzaldehyde	8270C/D	330	248	120	10	123
Bis (2-chloroethoxy)methane	8270C/D	330	248	81	45	110
Bis (2-Chloroethyl) Ether	8270C/D	330	248	96	40	105
Bis(2-ethylhexyl)phthalate	8270C/D	330	248	98	45	125
Butylbenzylphthalate	8270C/D	330	248	93	50	125
Caprolactam	8270C/D	330	248	144	30	140
Carbazole	8270C/D	330	248	111	45	115
Dibenzofuran	8270C/D	330	248	79	50	105
Diethyl phthalate	8270C/D	330	248	80	50	115
Dimethyl phthalate	8270C/D	330	248	78	50	110
Di-n-butyl phthalate	8270C/D	330	248	101	55	110
Di-n-octyl phthalate	8270C/D	330	248	211	40	130
Hexachlorobenzene	8270C/D	330	248	82	45	120
Hexachlorobutadiene	8270C/D	330	248	83	40	115
Hexachlorocyclopentadiene	8270C/D	330	248	82	23	107
Hexachloroethane	8270C/D	330	248	96	35	110
Isophorone	8270C/D	330	248	75	45	110
Nitrobenzene	8270C/D	330	248	91	40	115
n-Nitroso-di-n-propylamine	8270C/D	330	248	83	40	115
n-Nitrosodiphenylamine	8270C/D	330	248	219	50	115
Pentachlorophenol	8270C/D	820	615	237	25	120
Phenol	8270C/D	330	248	156	40	100
Surrogates:						
2-Fluorophenol	8270C/D	---	---	---	45	105
Terphenyl-d14	8270C/D	---	---	---	30	125
2,4,6-Tribromophenol	8270C/D	---	---	---	35	125
2-Fluorobiphenyl	8270C/D	---	---	---	35	105
Phenol-d6	8270C/D	---	---	---	40	100

Target List	EPA Method	Soil LOQ	Soil LODs	Soil MDLs	DOD Limits Lower	DOD Limits High
Nitrobenzene-d5	8270C/D	---	---	---	35	100
Semivolatile Organic SIM Compounds		**ug/Kg**	**ug/L**	**ug/Kg**		
1,4-Dioxane	8270C/D SIM	100	50	1.1	30	150
2-Methylnaphthalene	8270C/D SIM	20	10	2.2	10	152
Acenaphthene	8270C/D SIM	20	10	1.5	33	98
Acenaphthylene	8270C/D SIM	20	10	1.2	25	94
Anthracene	8270C/D SIM	20	10	1.2	34	96
Benzo(a)anthracene	8270C/D SIM	20	10	1.9	48	100
Benzo(a)pyrene	8270C/D SIM	20	10	3.3	61	101
Benzo(b)fluoranthene	8270C/D SIM	20	10	2.4	53	100
Benzo(g,h,i)perylene	8270C/D SIM	20	10	2.0	53	103
Benzo(k)fluoranthene	8270C/D SIM	20	10	3.1	49	96
Chrysene	8270C/D SIM	20	10	1.7	46	101
Dibenzo(a,h)anthracene	8270C/D SIM	20	10	1.8	55	105
Fluoranthene	8270C/D SIM	20	10	1.8	38	116
Fluorene	8270C/D SIM	20	10	3.2	40	92
Indeno(1,2,3-cd)pyrene	8270C/D SIM	20	10	1.9	50	105
Naphthalene	8270C/D SIM	20	10	2.6	10	129
Phenanthrene	8270C/D SIM	20	10	1.8	46	96
Pyrene	8270C/D SIM	20	10	2.1	35	111
Surrogates:						
2-Methylnaphthalene-D10	8270C/D SIM	---	---	---	19	94
Fluorene-D10	8270C/D SIM	---	---	---	20	96
Pyrene-D10	8270C/D SIM	---	---	---	31	128
Exposives		**ug/Kg**	**ug/Kg**	**ug/Kg**	**Soil**	**Soil**
1,3,5-Trinitrobenzene	8330B	100	50	6.7	75	125
1,3-Dinitrobenzene	8330B	100	50	6.2	80	125
2,4,6-Trinitrotoluene	8330B	100	50	6.7	55	140
2,4-Dinitrotoluene	8330B	100	50	15	80	125
2,6-Dinitrotoluene	8330B	100	50	27	80	120
2-Amino-4,6-dinitrotoluene	8330B	100	50	21	80	125
2-Nitrotoluene	8330B	100	50	12	80	125
3,5-Dinitroaniline	8330B	100	50	3.5	30	150
3-Nitrotoluene	8330B	100	50	7.9	75	120
4-Amino-2,6-dinitrotoluene	8330B	100	50	17	80	125
4-Nitrotoluene	8330B	100	50	27	75	125
HMX	8330B	100	50	8.6	75	125
Nitrobenzene	8330B	100	50	22	75	125
Nitroglycerin	8330B	800	400	124	30	150

Target List	EPA Method	Soil LOQ	Soil LODs	Soil MDLs	DOD Limits Lower	DOD Limits High
PETN	8330B	800	400	108	30	150
RDX	8330B	**100**	**50**	**6.8**	70	135
Tetryl	8330B	100	50	5.4	10	150
Surrogates:						
1,2-Dinitrobenzene	8330B	---	---	---	51	115
Pesticides		**ug/Kg**	**ug/L**	**ug/Kg**	**Soil**	**Soil**
4,4'-DDD	8081B	3.3	1.65	0.20	30	135
4,4'-DDE	8081B	3.3	1.65	0.19	70	125
4,4'-DDT	8081B	3.3	1.65	0.31	45	140
Aldrin	8081B	1.7	0.85	0.28	45	140
Alpha-BHC	8081B	1.7	0.85	0.34	60	125
Alpha-Chlordane	8081B	1.7	0.85	0.21	65	120
Beta-BHC	8081B	1.7	0.85	0.33	60	125
Delta-BHC	8081B	1.7	0.85	0.32	55	130
Dieldrin	8081B	3.3	1.65	0.22	65	125
Endosulfan I	8081B	1.7	0.85	0.24	15	135
Endosulfan II	8081B	3.3	1.65	0.34	35	140
Endosulfan Sulfate	8081B	3.3	1.65	0.58	60	135
Endrin	8081B	3.3	1.65	0.85	60	135
Endrin Aldehyde	8081B	3.3	1.65	0.49	35	145
Endrin Ketone	8081B	3.3	1.65	0.40	65	135
Gamma-BHC(Lindane)	8081B	1.7	0.85	0.27	60	125
Gamma-Chlordane	8081B	1.7	0.85	0.23	65	125
Heptachlor	8081B	1.7	0.85	0.29	50	140
Heptachlor Epoxide	8081B	1.7	0.85	0.22	65	130
Methoxychlor	8081B	17	8.5	0.5	55	145
Toxaphene	8081B	33	16	7.0	50	150
Surrogates:						
Decachlorobiphenyl	8081B	---	---	---	55	130
Tetrachloro-m-xylene	8081B	---	---	---	70	125
Polychorinated Biphenyls		**ug/Kg**	**ug/Kg**	**ug/Kg**	**Soil**	**Soil**
Aroclor 1016	8082A	17	8.5	6.0	40	140
Aroclor 1221	8082A	17	8.5	7.9	NA	NA
Aroclor 1232	8082A	17	10	9.3	NA	NA
Aroclor 1242	8082A	17	8.5	5.8	NA	NA
Aroclor 1248	8082A	17	8.5	6.1	NA	NA
Aroclor 1254	8082A	17	8.5	4.7	NA	NA
Aroclor 1260	8082A	17	8.5	6.0	60	130

Target List	EPA Method	Soil LOQ	Soil LODs	Soil MDLs	DOD Limits Lower	DOD Limits High
Aroclor 1262	8082A	17	8.5	2.5	NA	NA
Aroclor 1268	8082A	17	8.5	2.5	NA	NA
Surrogates:						
Decachlorobiphenyl	8082A	---	---	---	60	125
Tetrachloro-m-xylene	8082A	---	---	---	56	115
Metals - ICPMS		**mg/Kg**	**ug/L**	**mg/Kg**		
Aluminum	6020A (5)	30	4.0	0.51	80	120
Antimony	6020A (5)	0.1	0.05	0.020	80	120
Arsenic	6020A (5)	0.50	0.40	0.15	80	120
Barium	6020A (5)	0.20	0.10	0.037	80	120
Beryllium	6020A (5)	0.10	0.020	0.0041	80	120
Cadmium	6020A (5)	0.1	0.020	0.0076	80	120
Calcium	6020A (5)	10	8.0	3.83	80	120
Chromium	6020A (5)	0.40	0.30	0.05	80	120
Cobalt	6020A (5)	0.10	0.030	0.0054	80	120
Copper	6020A (5)	0.30	0.20	0.071	80	120
Iron	6020A (5)	10	6.0	2.40	80	120
Lead	6020A (5)	0.10	0.050	0.0070	80	120
Magnesium	6020A (5)	10	8.0	1.37	80	120
Manganese	6020A (5)	0.20	0.10	0.042	80	120
Nickel	6020A (5)	0.20	0.12	0.026	80	120
Potassium	6020A (5)	100	40	4.6	80	120
Selenium	6020A (5)	0.50	0.30	0.039	80	120
Silver	6020A (5)	0.10	0.040	0.0066	80	120
Sodium	6020A (5)	100	40	2.6	80	120
Thallium	6020A (5)	0.10	0.04	0.0094	80	120
Vanadium	6020A (5)	0.50	0.40	0.11	80	120
Zinc	6020A (5)	1.0	0.80	0.13	80	120
Metals - Mercury		**mg/Kg**	**mg/Kg**	**mg/Kg**		
Mercury	7471B/7470A	0.033	0.017	0.0052	80	120

State of Maine

Laboratory Certification Program

Awards Certification To

Katahdin Analytical Services

Located at

600 Technology Way
Scarborough, ME, 04074

For the demonstration of capability of performing the analyses listed on the attached certified analytes list(s) as required by 22 M.R.S.A., Chapter 157-A.

Laboratory ID: ME00019
Certificate Number: 2010040
Date of Issue: 6/1/2010
Expiration Date: 6/1/2012

Certification Officer

This certificate must be displayed with the corresponding analyte list.
This certificate supersedes all previously issued certificates.
Continuing certification status is dependent on successful ongoing participation in the program.
Customers may verify the laboratory's current certification status by calling (207) 287-1929.

Maine Center for Disease Control and Prevention
An Office of the Department of Health and Human Services
John E. Baldacci, Governor Brenda M. Harvey, Commissioner

Department of Health and Human Services
Maine Center for Disease Control and Prevention
286 Water Street
11 State House Station
Augusta, Maine 04333-0011
Tel: (207) 287-1929; Fax: (207) 287-4172
TTY: 1-800-606-0215

Field of Testing Summary for:

Katahdin Analytical Services

(207) 874-2400

600 Technology Way
Scarborough ME 04074

As required by 22 M.R.S.A Chapter 157-A the laboratory demonstrated the capability to analyze analtyes under 10-144 CMR 263, the rules for laboratory certification and is hereby granted certification for:

ASTM D516-02	
Sulfate	Clean Water Program (NPW)
EPA 1010A	
Ignitability	Resource Conservation Recovery Program (NPW)
Ignitability	Resource Conservation Recovery Program (S)
EPA 120.1	
Conductivity	Clean Water Program (NPW)
EPA 1311	
Extraction/Preparation	Resource Conservation Recovery Program (NPW)
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 1312	
Extraction/Preparation	Resource Conservation Recovery Program (NPW)
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 1631B	
Mercury	Clean Water Program (NPW)
EPA 1664A	
Oil & Grease	Clean Water Program (NPW)
EPA 1664A (HEM)	
n-Hexane Extractable Material (O&G)	Clean Water Program (NPW)
EPA 180.1 2	
Turbidity	Safe Drinking Water Program (DW)
EPA 200.7 4.4	
Aluminum	Clean Water Program (NPW)
Antimony	Clean Water Program (NPW)
Arsenic	Clean Water Program (NPW)
Barium	Clean Water Program (NPW)
Barium	Safe Drinking Water Program (DW)
Beryllium	Clean Water Program (NPW)
Beryllium	Safe Drinking Water Program (DW)
Boron	Clean Water Program (NPW)
Cadmium	Clean Water Program (NPW)
Cadmium	Safe Drinking Water Program (DW)
Calcium	Clean Water Program (NPW)
Calcium	Safe Drinking Water Program (DW)
Chromium	Clean Water Program (NPW)
Chromium	Safe Drinking Water Program (DW)
Cobalt	Clean Water Program (NPW)
Copper	Clean Water Program (NPW)
Copper	Safe Drinking Water Program (DW)
Iron	Clean Water Program (NPW)
Lead	Clean Water Program (NPW)
Magnesium	Clean Water Program (NPW)
Magnesium	Safe Drinking Water Program (DW)
Manganese	Clean Water Program (NPW)
Molybdenum	Clean Water Program (NPW)

To be considered valid, this Fields of Testing Summary must be displayed with a current certificate.

ME00019
Certificate Number: 2010040
FOT Issue Date: 6/22/2010
Expiration Date: 6/1/2012

Matthew J. Sica, Certification Officer

Nickel	Clean Water Program (NPW)
Nickel	Safe Drinking Water Program (DW)
Potassium	Clean Water Program (NPW)
Selenium	Clean Water Program (NPW)
Silica as SiO2	Clean Water Program (NPW)
Silica as SiO2	Safe Drinking Water Program (DW)
Silver	Clean Water Program (NPW)
Sodium	Clean Water Program (NPW)
Sodium	Safe Drinking Water Program (DW)
Thallium	Clean Water Program (NPW)
Tin	Clean Water Program (NPW)
Vanadium	Clean Water Program (NPW)
Zinc	Clean Water Program (NPW)
EPA 200.8 5.4	
Aluminum	Clean Water Program (NPW)
Antimony	Clean Water Program (NPW)
Antimony	Safe Drinking Water Program (DW)
Arsenic	Clean Water Program (NPW)
Arsenic	Safe Drinking Water Program (DW)
Barium	Clean Water Program (NPW)
Barium	Safe Drinking Water Program (DW)
Beryllium	Clean Water Program (NPW)
Beryllium	Safe Drinking Water Program (DW)
Cadmium	Clean Water Program (NPW)
Cadmium	Safe Drinking Water Program (DW)
Calcium	Clean Water Program (NPW)
Chromium	Clean Water Program (NPW)
Chromium	Safe Drinking Water Program (DW)
Cobalt	Clean Water Program (NPW)
Copper	Clean Water Program (NPW)
Copper	Safe Drinking Water Program (DW)
Lead	Clean Water Program (NPW)
Lead	Safe Drinking Water Program (DW)
Manganese	Clean Water Program (NPW)
Molybdenum	Clean Water Program (NPW)
Nickel	Clean Water Program (NPW)
Nickel	Safe Drinking Water Program (DW)
Selenium	Clean Water Program (NPW)
Selenium	Safe Drinking Water Program (DW)
Silver	Clean Water Program (NPW)
Thallium	Clean Water Program (NPW)
Thallium	Safe Drinking Water Program (DW)
Uranium	Safe Drinking Water Program (DW)
Vanadium	Clean Water Program (NPW)
Zinc	Clean Water Program (NPW)
EPA 245.1 3	
Mercury	Clean Water Program (NPW)
Mercury	Safe Drinking Water Program (DW)
EPA 300.0 2.1	
Bromide	Clean Water Program (NPW)
Bromide	Safe Drinking Water Program (DW)
Chloride	Clean Water Program (NPW)
Nitrate as N	Clean Water Program (NPW)
Nitrate as N	Safe Drinking Water Program (DW)
Nitrite as N	Safe Drinking Water Program (DW)
Orthophosphate as P	Clean Water Program (NPW)
Sulfate	Clean Water Program (NPW)
EPA 300.1 1	
Nitrite as N	Clean Water Program (NPW)
EPA 3005A	
Extraction/Preparation	Resource Conservation Recovery Program (NPW)
EPA 3050A	
Extraction/Preparation	Resource Conservation Recovery Program (S)

EPA 3050B	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 3060A	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 335.4	
Total Cyanide	Clean Water Program (NPW)
Total Cyanide	Safe Drinking Water Program (DW)
EPA 350.1 2	
Ammonia as N	Clean Water Program (NPW)
EPA 351.2 2	
Kjeldahl nitrogen - total	Clean Water Program (NPW)
EPA 3510C	
Extraction/Preparation	Resource Conservation Recovery Program (NPW)
EPA 3520C	
Extraction/Preparation	Resource Conservation Recovery Program (NPW)
EPA 353.2 2	
Nitrate as N	Clean Water Program (NPW)
Nitrate as N	Safe Drinking Water Program (DW)
Nitrite as N	Clean Water Program (NPW)
Nitrite as N	Safe Drinking Water Program (DW)
EPA 3540C	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 3545A	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 3550B	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 3580A	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 3640A	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 365.4	
Phosphorus, total	Clean Water Program (NPW)
EPA 3660B	
Extraction/Preparation	Resource Conservation Recovery Program (S)
EPA 410.4 2	
Chemical oxygen demand	Clean Water Program (NPW)
EPA 420.1	
Total Phenolics	Clean Water Program (NPW)
EPA 504.1 1.1	
1,2-Dibromo-3-chloropropane (DBCP)	Safe Drinking Water Program (DW)
1,2-Dibromoethane (EDB, Ethylene dibromide)	Safe Drinking Water Program (DW)
EPA 524.2 4.1	
1,1,1-Trichloroethane	Safe Drinking Water Program (DW)
1,1,2-Trichloroethane	Safe Drinking Water Program (DW)
1,1-Dichloroethylene	Safe Drinking Water Program (DW)
1,2,4-Trichlorobenzene	Safe Drinking Water Program (DW)
1,2-Dichlorobenzene	Safe Drinking Water Program (DW)
1,2-Dichloroethane	Safe Drinking Water Program (DW)
1,2-Dichloropropane	Safe Drinking Water Program (DW)
1,4-Dichlorobenzene	Safe Drinking Water Program (DW)
Benzene	Safe Drinking Water Program (DW)
Bromodichloromethane	Safe Drinking Water Program (DW)
Bromoform	Safe Drinking Water Program (DW)
Carbon tetrachloride	Safe Drinking Water Program (DW)
Chlorobenzene	Safe Drinking Water Program (DW)
Chloroform	Safe Drinking Water Program (DW)
cis-1,2-Dichloroethylene	Safe Drinking Water Program (DW)
Dibromochloromethane	Safe Drinking Water Program (DW)
Dichloromethane (Methylene chloride)	Safe Drinking Water Program (DW)
Ethylbenzene	Safe Drinking Water Program (DW)
Styrene	Safe Drinking Water Program (DW)
Tetrachloroethylene	Safe Drinking Water Program (DW)

Toluene	Safe Drinking Water Program (DW)
Total Trihalomethanes	Safe Drinking Water Program (DW)
trans-1,2-Dicloroethylene	Safe Drinking Water Program (DW)
Trichloroethene (Trichloroethylene)	Safe Drinking Water Program (DW)
Vinyl chloride	Safe Drinking Water Program (DW)
Xylene (total)	Safe Drinking Water Program (DW)
EPA 6010B	
Aluminum	Resource Conservation Recovery Program (NPW)
Aluminum	Resource Conservation Recovery Program (S)
Antimony	Resource Conservation Recovery Program (NPW)
Antimony	Resource Conservation Recovery Program (S)
Arsenic	Resource Conservation Recovery Program (NPW)
Arsenic	Resource Conservation Recovery Program (S)
Barium	Resource Conservation Recovery Program (NPW)
Barium	Resource Conservation Recovery Program (S)
Beryllium	Resource Conservation Recovery Program (NPW)
Beryllium	Resource Conservation Recovery Program (S)
Boron	Resource Conservation Recovery Program (NPW)
Boron	Resource Conservation Recovery Program (S)
Cadmium	Resource Conservation Recovery Program (NPW)
Cadmium	Resource Conservation Recovery Program (S)
Calcium	Resource Conservation Recovery Program (NPW)
Calcium	Resource Conservation Recovery Program (S)
Chromium	Resource Conservation Recovery Program (NPW)
Chromium	Resource Conservation Recovery Program (S)
Cobalt	Resource Conservation Recovery Program (NPW)
Cobalt	Resource Conservation Recovery Program (S)
Copper	Resource Conservation Recovery Program (NPW)
Copper	Resource Conservation Recovery Program (S)
Hardness (calc.)	Resource Conservation Recovery Program (NPW)
Hardness (calc.)	Resource Conservation Recovery Program (S)
Iron	Resource Conservation Recovery Program (NPW)
Iron	Resource Conservation Recovery Program (S)
Lead	Resource Conservation Recovery Program (NPW)
Lead	Resource Conservation Recovery Program (S)
Magnesium	Resource Conservation Recovery Program (NPW)
Magnesium	Resource Conservation Recovery Program (S)
Manganese	Resource Conservation Recovery Program (NPW)
Manganese	Resource Conservation Recovery Program (S)
Molybdenum	Resource Conservation Recovery Program (NPW)
Molybdenum	Resource Conservation Recovery Program (S)
Nickel	Resource Conservation Recovery Program (NPW)
Nickel	Resource Conservation Recovery Program (S)
Potassium	Resource Conservation Recovery Program (NPW)
Potassium	Resource Conservation Recovery Program (S)
Selenium	Resource Conservation Recovery Program (NPW)
Selenium	Resource Conservation Recovery Program (S)
Silicon	Resource Conservation Recovery Program (NPW)
Silicon	Resource Conservation Recovery Program (S)
Silver	Resource Conservation Recovery Program (NPW)
Silver	Resource Conservation Recovery Program (S)
Sodium	Resource Conservation Recovery Program (NPW)
Sodium	Resource Conservation Recovery Program (S)
Strontium	Resource Conservation Recovery Program (NPW)
Strontium	Resource Conservation Recovery Program (S)
Thallium	Resource Conservation Recovery Program (NPW)
Thallium	Resource Conservation Recovery Program (S)
Tin	Resource Conservation Recovery Program (NPW)
Tin	Resource Conservation Recovery Program (S)
Vanadium	Resource Conservation Recovery Program (NPW)
Vanadium	Resource Conservation Recovery Program (S)
Zinc	Resource Conservation Recovery Program (NPW)
Zinc	Resource Conservation Recovery Program (S)
EPA 6010C	

Aluminum	Resource Conservation Recovery Program (NPW)
Aluminum	Resource Conservation Recovery Program (S)
Antimony	Resource Conservation Recovery Program (NPW)
Antimony	Resource Conservation Recovery Program (S)
Arsenic	Resource Conservation Recovery Program (NPW)
Arsenic	Resource Conservation Recovery Program (S)
Barium	Resource Conservation Recovery Program (NPW)
Barium	Resource Conservation Recovery Program (S)
Beryllium	Resource Conservation Recovery Program (NPW)
Beryllium	Resource Conservation Recovery Program (S)
Boron	Resource Conservation Recovery Program (NPW)
Boron	Resource Conservation Recovery Program (S)
Cadmium	Resource Conservation Recovery Program (NPW)
Cadmium	Resource Conservation Recovery Program (S)
Calcium	Resource Conservation Recovery Program (NPW)
Calcium	Resource Conservation Recovery Program (S)
Chromium	Resource Conservation Recovery Program (NPW)
Chromium	Resource Conservation Recovery Program (S)
Cobalt	Resource Conservation Recovery Program (NPW)
Cobalt	Resource Conservation Recovery Program (S)
Copper	Resource Conservation Recovery Program (NPW)
Copper	Resource Conservation Recovery Program (S)
Iron	Resource Conservation Recovery Program (NPW)
Iron	Resource Conservation Recovery Program (S)
Lead	Resource Conservation Recovery Program (NPW)
Lead	Resource Conservation Recovery Program (S)
Magnesium	Resource Conservation Recovery Program (NPW)
Magnesium	Resource Conservation Recovery Program (S)
Manganese	Resource Conservation Recovery Program (NPW)
Manganese	Resource Conservation Recovery Program (S)
Molybdenum	Resource Conservation Recovery Program (NPW)
Molybdenum	Resource Conservation Recovery Program (S)
Nickel	Resource Conservation Recovery Program (NPW)
Nickel	Resource Conservation Recovery Program (S)
Potassium	Resource Conservation Recovery Program (NPW)
Potassium	Resource Conservation Recovery Program (S)
Selenium	Resource Conservation Recovery Program (NPW)
Selenium	Resource Conservation Recovery Program (S)
Silicon	Resource Conservation Recovery Program (NPW)
Silicon	Resource Conservation Recovery Program (S)
Silver	Resource Conservation Recovery Program (NPW)
Silver	Resource Conservation Recovery Program (S)
Sodium	Resource Conservation Recovery Program (NPW)
Sodium	Resource Conservation Recovery Program (S)
Strontium	Resource Conservation Recovery Program (NPW)
Strontium	Resource Conservation Recovery Program (S)
Thallium	Resource Conservation Recovery Program (NPW)
Thallium	Resource Conservation Recovery Program (S)
Tin	Resource Conservation Recovery Program (NPW)
Tin	Resource Conservation Recovery Program (S)
Vanadium	Resource Conservation Recovery Program (NPW)
Vanadium	Resource Conservation Recovery Program (S)
Zinc	Resource Conservation Recovery Program (NPW)
Zinc	Resource Conservation Recovery Program (S)
EPA 6020	
Aluminum	Resource Conservation Recovery Program (NPW)
Aluminum	Resource Conservation Recovery Program (S)
Antimony	Resource Conservation Recovery Program (NPW)
Antimony	Resource Conservation Recovery Program (S)
Arsenic	Resource Conservation Recovery Program (NPW)
Arsenic	Resource Conservation Recovery Program (S)
Barium	Resource Conservation Recovery Program (NPW)
Barium	Resource Conservation Recovery Program (S)
Beryllium	Resource Conservation Recovery Program (NPW)

Beryllium	Resource Conservation Recovery Program (S)
Boron	Resource Conservation Recovery Program (NPW)
Boron	Resource Conservation Recovery Program (S)
Cadmium	Resource Conservation Recovery Program (NPW)
Cadmium	Resource Conservation Recovery Program (S)
Calcium	Resource Conservation Recovery Program (NPW)
Calcium	Resource Conservation Recovery Program (S)
Chromium	Resource Conservation Recovery Program (NPW)
Chromium	Resource Conservation Recovery Program (S)
Cobalt	Resource Conservation Recovery Program (NPW)
Cobalt	Resource Conservation Recovery Program (S)
Copper	Resource Conservation Recovery Program (NPW)
Copper	Resource Conservation Recovery Program (S)
Iron	Resource Conservation Recovery Program (NPW)
Iron	Resource Conservation Recovery Program (S)
Lead	Resource Conservation Recovery Program (NPW)
Lead	Resource Conservation Recovery Program (S)
Magnesium	Resource Conservation Recovery Program (NPW)
Magnesium	Resource Conservation Recovery Program (S)
Manganese	Resource Conservation Recovery Program (NPW)
Manganese	Resource Conservation Recovery Program (S)
Molybdenum	Resource Conservation Recovery Program (NPW)
Molybdenum	Resource Conservation Recovery Program (S)
Nickel	Resource Conservation Recovery Program (NPW)
Nickel	Resource Conservation Recovery Program (S)
Potassium	Resource Conservation Recovery Program (NPW)
Potassium	Resource Conservation Recovery Program (S)
Selenium	Resource Conservation Recovery Program (NPW)
Selenium	Resource Conservation Recovery Program (S)
Silver	Resource Conservation Recovery Program (NPW)
Silver	Resource Conservation Recovery Program (S)
Sodium	Resource Conservation Recovery Program (NPW)
Sodium	Resource Conservation Recovery Program (S)
Strontium	Resource Conservation Recovery Program (NPW)
Strontium	Resource Conservation Recovery Program (S)
Thallium	Resource Conservation Recovery Program (NPW)
Thallium	Resource Conservation Recovery Program (S)
Tin	Resource Conservation Recovery Program (NPW)
Tin	Resource Conservation Recovery Program (S)
Uranium	Resource Conservation Recovery Program (NPW)
Uranium	Resource Conservation Recovery Program (S)
Vanadium	Resource Conservation Recovery Program (NPW)
Vanadium	Resource Conservation Recovery Program (S)
Zinc	Resource Conservation Recovery Program (NPW)
Zinc	Resource Conservation Recovery Program (S)
EPA 6020A	
Aluminum	Resource Conservation Recovery Program (NPW)
Aluminum	Resource Conservation Recovery Program (S)
Antimony	Resource Conservation Recovery Program (NPW)
Antimony	Resource Conservation Recovery Program (S)
Arsenic	Resource Conservation Recovery Program (NPW)
Arsenic	Resource Conservation Recovery Program (S)
Barium	Resource Conservation Recovery Program (NPW)
Barium	Resource Conservation Recovery Program (S)
Beryllium	Resource Conservation Recovery Program (NPW)
Beryllium	Resource Conservation Recovery Program (S)
Boron	Resource Conservation Recovery Program (NPW)
Boron	Resource Conservation Recovery Program (S)
Cadmium	Resource Conservation Recovery Program (NPW)
Cadmium	Resource Conservation Recovery Program (S)
Calcium	Resource Conservation Recovery Program (NPW)
Calcium	Resource Conservation Recovery Program (S)
Chromium	Resource Conservation Recovery Program (NPW)
Chromium	Resource Conservation Recovery Program (S)

Cobalt	Resource Conservation Recovery Program (NPW)
Cobalt	Resource Conservation Recovery Program (S)
Copper	Resource Conservation Recovery Program (NPW)
Copper	Resource Conservation Recovery Program (S)
Iron	Resource Conservation Recovery Program (NPW)
Iron	Resource Conservation Recovery Program (S)
Lead	Resource Conservation Recovery Program (NPW)
Lead	Resource Conservation Recovery Program (S)
Magnesium	Resource Conservation Recovery Program (NPW)
Magnesium	Resource Conservation Recovery Program (S)
Manganese	Resource Conservation Recovery Program (NPW)
Manganese	Resource Conservation Recovery Program (S)
Molybdenum	Resource Conservation Recovery Program (NPW)
Molybdenum	Resource Conservation Recovery Program (S)
Nickel	Resource Conservation Recovery Program (NPW)
Nickel	Resource Conservation Recovery Program (S)
Potassium	Resource Conservation Recovery Program (NPW)
Potassium	Resource Conservation Recovery Program (S)
Selenium	Resource Conservation Recovery Program (NPW)
Selenium	Resource Conservation Recovery Program (S)
Silicon	Resource Conservation Recovery Program (NPW)
Silicon	Resource Conservation Recovery Program (S)
Silver	Resource Conservation Recovery Program (NPW)
Silver	Resource Conservation Recovery Program (S)
Sodium	Resource Conservation Recovery Program (NPW)
Sodium	Resource Conservation Recovery Program (S)
Strontium	Resource Conservation Recovery Program (NPW)
Strontium	Resource Conservation Recovery Program (S)
Thallium	Resource Conservation Recovery Program (NPW)
Thallium	Resource Conservation Recovery Program (S)
Tin	Resource Conservation Recovery Program (NPW)
Tin	Resource Conservation Recovery Program (S)
Uranium	Resource Conservation Recovery Program (NPW)
Uranium	Resource Conservation Recovery Program (S)
Vanadium	Resource Conservation Recovery Program (NPW)
Vanadium	Resource Conservation Recovery Program (S)
Zinc	Resource Conservation Recovery Program (NPW)
Zinc	Resource Conservation Recovery Program (S)
EPA 608	
4,4'-DDD	Clean Water Program (NPW)
4,4'-DDE	Clean Water Program (NPW)
4,4'-DDT	Clean Water Program (NPW)
Aldrin	Clean Water Program (NPW)
alpha-BHC	Clean Water Program (NPW)
Aroclor-1016 (PCB-1016)	Clean Water Program (NPW)
Aroclor-1221 (PCB-1221)	Clean Water Program (NPW)
Aroclor-1232 (PCB-1232)	Clean Water Program (NPW)
Aroclor-1242 (PCB-1242)	Clean Water Program (NPW)
Aroclor-1248 (PCB-1248)	Clean Water Program (NPW)
Aroclor-1254 (PCB-1254)	Clean Water Program (NPW)
Aroclor-1260 (PCB-1260)	Clean Water Program (NPW)
beta-BHC	Clean Water Program (NPW)
Chlordane (tech.)	Clean Water Program (NPW)
delta-BHC	Clean Water Program (NPW)
Dieldrin	Clean Water Program (NPW)
Endosulfan I	Clean Water Program (NPW)
Endosulfan II	Clean Water Program (NPW)
Endosulfan sulfate	Clean Water Program (NPW)
Endrin	Clean Water Program (NPW)
Endrin aldehyde	Clean Water Program (NPW)
gamma-BHC	Clean Water Program (NPW)
Heptachlor	Clean Water Program (NPW)
Heptachlor epoxide	Clean Water Program (NPW)
Toxaphene	Clean Water Program (NPW)

EPA 624

1,1,1-Trichloroethane	Clean Water Program (NPW)
1,1,2,2-Tetrachloroethane	Clean Water Program (NPW)
1,1,2-Trichloroethane	Clean Water Program (NPW)
1,1-Dichloroethane	Clean Water Program (NPW)
1,1-Dichloroethylene	Clean Water Program (NPW)
1,2-Dichlorobenzene	Clean Water Program (NPW)
1,2-Dichloroethane	Clean Water Program (NPW)
1,2-Dichloropropane	Clean Water Program (NPW)
1,3-Dichlorobenzene	Clean Water Program (NPW)
1,4-Dichlorobenzene	Clean Water Program (NPW)
2-Chloroethyl vinyl ether	Clean Water Program (NPW)
Acrolein	Clean Water Program (NPW)
Acrylonitrile	Clean Water Program (NPW)
Benzene	Clean Water Program (NPW)
Bromodichloromethane	Clean Water Program (NPW)
Bromoform	Clean Water Program (NPW)
Bromomethane (Methyl bromide)	Clean Water Program (NPW)
Carbon tetrachloride	Clean Water Program (NPW)
Chlorobenzene	Clean Water Program (NPW)
Chloroethane	Clean Water Program (NPW)
Chloroform	Clean Water Program (NPW)
cis-1,3-Dichloropropene	Clean Water Program (NPW)
Dibromochloromethane	Clean Water Program (NPW)
Dichlorodifluoromethane	Clean Water Program (NPW)
Dichloromethane (Methylene chloride)	Clean Water Program (NPW)
Ethylbenzene	Clean Water Program (NPW)
Methyl chloride (Chloromethane)	Clean Water Program (NPW)
Tetrachloroethylene	Clean Water Program (NPW)
Toluene	Clean Water Program (NPW)
trans-1,2-Dicloroethylene	Clean Water Program (NPW)
trans-1,3-Dichloropropylene	Clean Water Program (NPW)
Trichloroethene (Trichloroethylene)	Clean Water Program (NPW)
Trichlorofluoromethane	Clean Water Program (NPW)
Vinyl chloride	Clean Water Program (NPW)

EPA 625

1,2,4-Trichlorobenzene	Clean Water Program (NPW)
2,4,6-Trichlorophenol	Clean Water Program (NPW)
2,4-Dichlorophenol	Clean Water Program (NPW)
2,4-Dimethylphenol	Clean Water Program (NPW)
2,4-Dinitrophenol	Clean Water Program (NPW)
2,4-Dinitrotoluene (2,4-DNT)	Clean Water Program (NPW)
2,6-Dinitrotoluene (2,6-DNT)	Clean Water Program (NPW)
2-Chloronaphthalene	Clean Water Program (NPW)
2-Chlorophenol	Clean Water Program (NPW)
2-Methyl-4,6-dinitrophenol	Clean Water Program (NPW)
2-Nitrophenol	Clean Water Program (NPW)
3,3'-Dichlorobenzidine	Clean Water Program (NPW)
4,6-Dinitro-2-methylphenol	Clean Water Program (NPW)
4-Bromophenyl phenyl ether	Clean Water Program (NPW)
4-Chloro-3-methylphenol	Clean Water Program (NPW)
4-Chlorophenyl phenylether	Clean Water Program (NPW)
4-Nitrophenol	Clean Water Program (NPW)
Acenaphthene	Clean Water Program (NPW)
Acenaphthylene	Clean Water Program (NPW)
Anthracene	Clean Water Program (NPW)
Benzidine	Clean Water Program (NPW)
Benzo[a]anthracene	Clean Water Program (NPW)
Benzo[a]pyrene	Clean Water Program (NPW)
Benzo[b]fluoranthene	Clean Water Program (NPW)
Benzo[g,h,i]perylene	Clean Water Program (NPW)
Benzo[k]fluoranthene	Clean Water Program (NPW)
bis(2-Chloroethoxy)methane	Clean Water Program (NPW)
bis(2-Chloroethyl)ether	Clean Water Program (NPW)

bis(2-Chloroisopropyl)ether	Clean Water Program (NPW)
bis(2-Ethylhexyl)phthalate (DEHP)	Clean Water Program (NPW)
Butyl benzyl phthalate	Clean Water Program (NPW)
Chrysene	Clean Water Program (NPW)
Dibenz[a,h]anthracene	Clean Water Program (NPW)
Diethyl phthalate	Clean Water Program (NPW)
Dimethyl phthalate	Clean Water Program (NPW)
Di-n-butyl phthalate	Clean Water Program (NPW)
Di-n-octyl phthalate	Clean Water Program (NPW)
Fluoranthene	Clean Water Program (NPW)
Fluorene	Clean Water Program (NPW)
Hexachlorobenzene	Clean Water Program (NPW)
Hexachlorobutadiene	Clean Water Program (NPW)
Hexachlorocyclopentadiene	Clean Water Program (NPW)
Hexachloroethane	Clean Water Program (NPW)
Indeno[1,2,3-cd]pyrene	Clean Water Program (NPW)
Isophorone	Clean Water Program (NPW)
Naphthalene	Clean Water Program (NPW)
Nitrobenzene	Clean Water Program (NPW)
n-Nitrosodimethylamine	Clean Water Program (NPW)
n-Nitroso-di-n-propylamine	Clean Water Program (NPW)
n-Nitrosodiphenylamine	Clean Water Program (NPW)
Pentachlorophenol	Clean Water Program (NPW)
Phenanthrene	Clean Water Program (NPW)
Phenol	Clean Water Program (NPW)
Pyrene	Clean Water Program (NPW)
EPA 7196A 1	
Chromium VI	Resource Conservation Recovery Program (NPW)
Chromium VI	Resource Conservation Recovery Program (S)
EPA 7470A	
Mercury	Resource Conservation Recovery Program (NPW)
EPA 7471A	
Mercury	Resource Conservation Recovery Program (S)
EPA 7471B	
Mercury	Resource Conservation Recovery Program (S)
EPA 8015B	
Ethanol	Resource Conservation Recovery Program (S)
Ethylene glycol	Resource Conservation Recovery Program (S)
Isopropyl alcohol	Resource Conservation Recovery Program (S)
Methanol	Resource Conservation Recovery Program (S)
Propylene Glycol	Resource Conservation Recovery Program (S)
EPA 8015C	
Ethanol	Resource Conservation Recovery Program (S)
Isopropanol	Resource Conservation Recovery Program (S)
Methanol	Resource Conservation Recovery Program (S)
EPA 8081A	
4,4'-DDD	Resource Conservation Recovery Program (NPW)
4,4'-DDD	Resource Conservation Recovery Program (S)
4,4'-DDE	Resource Conservation Recovery Program (NPW)
4,4'-DDE	Resource Conservation Recovery Program (S)
4,4'-DDT	Resource Conservation Recovery Program (NPW)
4,4'-DDT	Resource Conservation Recovery Program (S)
Aldrin	Resource Conservation Recovery Program (NPW)
Aldrin	Resource Conservation Recovery Program (S)
alpha-BHC	Resource Conservation Recovery Program (NPW)
alpha-BHC	Resource Conservation Recovery Program (S)
alpha-Chlordane	Resource Conservation Recovery Program (NPW)
alpha-Chlordane	Resource Conservation Recovery Program (S)
beta-BHC	Resource Conservation Recovery Program (NPW)
beta-BHC	Resource Conservation Recovery Program (S)
Chlordane (tech.)	Resource Conservation Recovery Program (NPW)
Chlordane (tech.)	Resource Conservation Recovery Program (S)
delta-BHC	Resource Conservation Recovery Program (NPW)

delta-BHC	Resource Conservation Recovery Program (S)
Dieldrin	Resource Conservation Recovery Program (NPW)
Dieldrin	Resource Conservation Recovery Program (S)
Endosulfan I	Resource Conservation Recovery Program (NPW)
Endosulfan I	Resource Conservation Recovery Program (S)
Endosulfan II	Resource Conservation Recovery Program (NPW)
Endosulfan II	Resource Conservation Recovery Program (S)
Endosulfan sulfate	Resource Conservation Recovery Program (NPW)
Endosulfan sulfate	Resource Conservation Recovery Program (S)
Endrin	Resource Conservation Recovery Program (NPW)
Endrin	Resource Conservation Recovery Program (S)
Endrin aldehyde	Resource Conservation Recovery Program (NPW)
Endrin aldehyde	Resource Conservation Recovery Program (S)
Endrin ketone	Resource Conservation Recovery Program (NPW)
Endrin ketone	Resource Conservation Recovery Program (S)
gamma-BHC	Resource Conservation Recovery Program (NPW)
gamma-BHC	Resource Conservation Recovery Program (S)
gamma-Chlordane	Resource Conservation Recovery Program (NPW)
gamma-Chlordane	Resource Conservation Recovery Program (S)
Heptachlor	Resource Conservation Recovery Program (NPW)
Heptachlor	Resource Conservation Recovery Program (S)
Heptachlor epoxide	Resource Conservation Recovery Program (NPW)
Heptachlor epoxide	Resource Conservation Recovery Program (S)
Methoxychlor	Resource Conservation Recovery Program (NPW)
Methoxychlor	Resource Conservation Recovery Program (S)
Toxaphene	Resource Conservation Recovery Program (NPW)
Toxaphene	Resource Conservation Recovery Program (S)
EPA 8081B	
4,4'-DDD	Resource Conservation Recovery Program (NPW)
4,4'-DDD	Resource Conservation Recovery Program (S)
4,4'-DDE	Resource Conservation Recovery Program (NPW)
4,4'-DDE	Resource Conservation Recovery Program (S)
4,4'-DDT	Resource Conservation Recovery Program (NPW)
4,4'-DDT	Resource Conservation Recovery Program (S)
Aldrin	Resource Conservation Recovery Program (NPW)
Aldrin	Resource Conservation Recovery Program (S)
alpha-BHC	Resource Conservation Recovery Program (NPW)
alpha-BHC	Resource Conservation Recovery Program (S)
alpha-Chlordane	Resource Conservation Recovery Program (NPW)
alpha-Chlordane	Resource Conservation Recovery Program (S)
beta-BHC	Resource Conservation Recovery Program (NPW)
beta-BHC	Resource Conservation Recovery Program (S)
Chlordane (tech.)	Resource Conservation Recovery Program (NPW)
Chlordane (tech.)	Resource Conservation Recovery Program (S)
delta-BHC	Resource Conservation Recovery Program (NPW)
delta-BHC	Resource Conservation Recovery Program (S)
Dieldrin	Resource Conservation Recovery Program (NPW)
Dieldrin	Resource Conservation Recovery Program (S)
Endosulfan I	Resource Conservation Recovery Program (NPW)
Endosulfan I	Resource Conservation Recovery Program (S)
Endosulfan II	Resource Conservation Recovery Program (NPW)
Endosulfan II	Resource Conservation Recovery Program (S)
Endosulfan sulfate	Resource Conservation Recovery Program (NPW)
Endosulfan sulfate	Resource Conservation Recovery Program (S)
Endrin	Resource Conservation Recovery Program (NPW)
Endrin	Resource Conservation Recovery Program (S)
Endrin aldehyde	Resource Conservation Recovery Program (NPW)
Endrin aldehyde	Resource Conservation Recovery Program (S)
Endrin ketone	Resource Conservation Recovery Program (NPW)
Endrin ketone	Resource Conservation Recovery Program (S)
gamma-BHC	Resource Conservation Recovery Program (NPW)
gamma-BHC	Resource Conservation Recovery Program (S)
gamma-Chlordane	Resource Conservation Recovery Program (NPW)
gamma-Chlordane	Resource Conservation Recovery Program (S)

Heptachlor	Resource Conservation Recovery Program (NPW)
Heptachlor	Resource Conservation Recovery Program (S)
Heptachlor epoxide	Resource Conservation Recovery Program (NPW)
Heptachlor epoxide	Resource Conservation Recovery Program (S)
Methoxychlor	Resource Conservation Recovery Program (NPW)
Methoxychlor	Resource Conservation Recovery Program (S)
Toxaphene	Resource Conservation Recovery Program (NPW)
Toxaphene	Resource Conservation Recovery Program (S)
EPA 8082	
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,3',4,4',5,6-Octachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,3',4,4',5,6-Octachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,3',4,4',5-Heptachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,3',4,4',5-Heptachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,3',4,4'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,3',4,4'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,4,4',5,5'-Heptachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,4,4',5,5'-Heptachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,4,4',5',6-Heptachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,4,4',5',6-Heptachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,4',5,5',6-Heptachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,4',5,5',6-Heptachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,4,5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,4,5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',4,5,5'-Pentachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',4,5,5'-Pentachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',5,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',5,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',5-Trichlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',5-Trichlorobiphenyl	Resource Conservation Recovery Program (S)
2,3,3',4,4',5,5'-Heptachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3,3',4,4',5,5'-Heptachlorobiphenyl	Resource Conservation Recovery Program (S)
2,3,3',4,4'-Pentachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3,3',4,4'-Pentachlorobiphenyl	Resource Conservation Recovery Program (S)
2,3',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
2,3',4,4',5'-Pentachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3',4,4',5'-Pentachlorobiphenyl	Resource Conservation Recovery Program (S)
2,3',4,4',5-Pentachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3',4,4',5-Pentachlorobiphenyl	Resource Conservation Recovery Program (S)
2,3,4,4',5-Pentachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3,4,4',5-Pentachlorobiphenyl	Resource Conservation Recovery Program (S)
2,3',4,4'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3',4,4'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
2,4,4'-Trichlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,4,4'-Trichlorobiphenyl	Resource Conservation Recovery Program (S)
2,4'-Dichlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,4'-Dichlorobiphenyl	Resource Conservation Recovery Program (S)
3,3',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
3,3',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
3,3',4,4',5-Pentachlorobiphenyl	Resource Conservation Recovery Program (NPW)
3,3',4,4',5-Pentachlorobiphenyl	Resource Conservation Recovery Program (S)
3,3',4,4'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
3,3',4,4'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
3,4,4',5-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
3,4,4',5-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
Aroclor-1016 (PCB-1016)	Resource Conservation Recovery Program (NPW)

Aroclor-1016 (PCB-1016)	Resource Conservation Recovery Program (S)
Aroclor-1221 (PCB-1221)	Resource Conservation Recovery Program (NPW)
Aroclor-1221 (PCB-1221)	Resource Conservation Recovery Program (S)
Aroclor-1232 (PCB-1232)	Resource Conservation Recovery Program (NPW)
Aroclor-1232 (PCB-1232)	Resource Conservation Recovery Program (S)
Aroclor-1242 (PCB-1242)	Resource Conservation Recovery Program (NPW)
Aroclor-1242 (PCB-1242)	Resource Conservation Recovery Program (S)
Aroclor-1248 (PCB-1248)	Resource Conservation Recovery Program (NPW)
Aroclor-1248 (PCB-1248)	Resource Conservation Recovery Program (S)
Aroclor-1254 (PCB-1254)	Resource Conservation Recovery Program (NPW)
Aroclor-1254 (PCB-1254)	Resource Conservation Recovery Program (S)
Aroclor-1260 (PCB-1260)	Resource Conservation Recovery Program (NPW)
Aroclor-1260 (PCB-1260)	Resource Conservation Recovery Program (S)
Aroclor-1262 (PCB 1262)	Resource Conservation Recovery Program (NPW)
Aroclor-1262 (PCB 1262)	Resource Conservation Recovery Program (S)
Aroclor-1268 (PCB-1268)	Resource Conservation Recovery Program (NPW)
Aroclor-1268 (PCB-1268)	Resource Conservation Recovery Program (S)
Decachlorobiphenyl	Resource Conservation Recovery Program (NPW)
Decachlorobiphenyl	Resource Conservation Recovery Program (S)
EPA 8082A	
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,4,4',5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,4,4',5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,4',5,5',6-Heptachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,4',5,5',6-Heptachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',3,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',3,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',4,4',5,5'-Hexachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',5,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',5,5'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
2,2',5-Trichlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,2',5-Trichlorobiphenyl	Resource Conservation Recovery Program (S)
2,3,3',4,4',5,5'-Heptachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3,3',4,4',5,5'-Heptachlorobiphenyl	Resource Conservation Recovery Program (S)
2,3',4,4'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (NPW)
2,3',4,4'-Tetrachlorobiphenyl	Resource Conservation Recovery Program (S)
Aroclor-1016 (PCB-1016)	Resource Conservation Recovery Program (NPW)
Aroclor-1016 (PCB-1016)	Resource Conservation Recovery Program (S)
Aroclor-1221 (PCB-1221)	Resource Conservation Recovery Program (NPW)
Aroclor-1221 (PCB-1221)	Resource Conservation Recovery Program (S)
Aroclor-1232 (PCB-1232)	Resource Conservation Recovery Program (NPW)
Aroclor-1232 (PCB-1232)	Resource Conservation Recovery Program (S)
Aroclor-1242 (PCB-1242)	Resource Conservation Recovery Program (NPW)
Aroclor-1242 (PCB-1242)	Resource Conservation Recovery Program (S)
Aroclor-1248 (PCB-1248)	Resource Conservation Recovery Program (NPW)
Aroclor-1248 (PCB-1248)	Resource Conservation Recovery Program (S)
Aroclor-1254 (PCB-1254)	Resource Conservation Recovery Program (NPW)
Aroclor-1254 (PCB-1254)	Resource Conservation Recovery Program (S)
Aroclor-1260 (PCB-1260)	Resource Conservation Recovery Program (NPW)
Aroclor-1260 (PCB-1260)	Resource Conservation Recovery Program (S)
Aroclor-1262 (PCB 1262)	Resource Conservation Recovery Program (NPW)
Aroclor-1262 (PCB 1262)	Resource Conservation Recovery Program (S)
Aroclor-1268 (PCB-1268)	Resource Conservation Recovery Program (NPW)
Aroclor-1268 (PCB-1268)	Resource Conservation Recovery Program (S)
EPA 8151A	
2,4,5-T	Resource Conservation Recovery Program (NPW)
2,4,5-T	Resource Conservation Recovery Program (S)
2,4-D	Resource Conservation Recovery Program (NPW)
2,4-D	Resource Conservation Recovery Program (S)
2,4-DB	Resource Conservation Recovery Program (NPW)
2,4-DB	Resource Conservation Recovery Program (S)
Dalapon	Resource Conservation Recovery Program (NPW)

Dalapon	Resource Conservation Recovery Program (S)
Dicamba	Resource Conservation Recovery Program (NPW)
Dicamba	Resource Conservation Recovery Program (S)
Dichloroprop	Resource Conservation Recovery Program (NPW)
Dichloroprop	Resource Conservation Recovery Program (S)
Dinoseb	Resource Conservation Recovery Program (NPW)
Dinoseb	Resource Conservation Recovery Program (S)
MCPA	Resource Conservation Recovery Program (NPW)
MCPA	Resource Conservation Recovery Program (S)
MCPP	Resource Conservation Recovery Program (NPW)
MCPP	Resource Conservation Recovery Program (S)
Pentachlorophenol	Resource Conservation Recovery Program (NPW)
Pentachlorophenol	Resource Conservation Recovery Program (S)
Silvex (2,4,5-TP)	Resource Conservation Recovery Program (NPW)
Silvex (2,4,5-TP)	Resource Conservation Recovery Program (S)
EPA 8260B	
1,1,1,2-Tetrachloroethane	Resource Conservation Recovery Program (NPW)
1,1,1,2-Tetrachloroethane	Resource Conservation Recovery Program (S)
1,1,1-Trichloroethane	Resource Conservation Recovery Program (NPW)
1,1,1-Trichloroethane	Resource Conservation Recovery Program (S)
1,1,2,2-Tetrachloroethane	Resource Conservation Recovery Program (NPW)
1,1,2,2-Tetrachloroethane	Resource Conservation Recovery Program (S)
1,1,2-Trichloro-1,2,2-trifluoroethane	Resource Conservation Recovery Program (NPW)
1,1,2-Trichloro-1,2,2-trifluoroethane	Resource Conservation Recovery Program (S)
1,1,2-Trichloroethane	Resource Conservation Recovery Program (NPW)
1,1,2-Trichloroethane	Resource Conservation Recovery Program (S)
1,1-Dichloroethane	Resource Conservation Recovery Program (NPW)
1,1-Dichloroethane	Resource Conservation Recovery Program (S)
1,1-Dichloroethylene	Resource Conservation Recovery Program (NPW)
1,1-Dichloroethylene	Resource Conservation Recovery Program (S)
1,1-Dichloropropene	Resource Conservation Recovery Program (NPW)
1,1-Dichloropropene	Resource Conservation Recovery Program (S)
1,2,3-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,3-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,2,3-Trichloropropane	Resource Conservation Recovery Program (NPW)
1,2,3-Trichloropropane	Resource Conservation Recovery Program (S)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,2,4-Trimethylbenzene	Resource Conservation Recovery Program (NPW)
1,2,4-Trimethylbenzene	Resource Conservation Recovery Program (S)
1,2-Dibromo-3-chloropropane (DBCP)	Resource Conservation Recovery Program (NPW)
1,2-Dibromo-3-chloropropane (DBCP)	Resource Conservation Recovery Program (S)
1,2-Dibromoethane (EDB, Ethylene dibromide)	Resource Conservation Recovery Program (NPW)
1,2-Dibromoethane (EDB, Ethylene dibromide)	Resource Conservation Recovery Program (S)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,2-Dichloroethane	Resource Conservation Recovery Program (NPW)
1,2-Dichloroethane	Resource Conservation Recovery Program (S)
1,2-Dichloropropane	Resource Conservation Recovery Program (NPW)
1,2-Dichloropropane	Resource Conservation Recovery Program (S)
1,3,5-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,3,5-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,3,5-Trimethylbenzene	Resource Conservation Recovery Program (NPW)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,3-Dichloropropane	Resource Conservation Recovery Program (NPW)
1,3-Dichloropropane	Resource Conservation Recovery Program (S)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (NPW)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (S)
1-Chlorohexane	Resource Conservation Recovery Program (NPW)
1-Chlorohexane	Resource Conservation Recovery Program (S)
2,2-Dichloropropane	Resource Conservation Recovery Program (NPW)

2,2-Dichloropropane	Resource Conservation Recovery Program (S)
2-Butanone (Methyl ethyl ketone, MEK)	Resource Conservation Recovery Program (NPW)
2-Butanone (Methyl ethyl ketone, MEK)	Resource Conservation Recovery Program (S)
2-Chloroethyl vinyl ether	Resource Conservation Recovery Program (NPW)
2-Chloroethyl vinyl ether	Resource Conservation Recovery Program (S)
2-Chlorotoluene	Resource Conservation Recovery Program (NPW)
2-Chlorotoluene	Resource Conservation Recovery Program (S)
2-Hexanone	Resource Conservation Recovery Program (NPW)
2-Hexanone	Resource Conservation Recovery Program (S)
4-Chlorotoluene	Resource Conservation Recovery Program (NPW)
4-Chlorotoluene	Resource Conservation Recovery Program (S)
4-Methyl-2-pentanone (MIBK)	Resource Conservation Recovery Program (NPW)
4-Methyl-2-pentanone (MIBK)	Resource Conservation Recovery Program (S)
Acetone	Resource Conservation Recovery Program (NPW)
Acetone	Resource Conservation Recovery Program (S)
Acetonitrile	Resource Conservation Recovery Program (NPW)
Acetonitrile	Resource Conservation Recovery Program (S)
Acrolein	Resource Conservation Recovery Program (NPW)
Acrolein	Resource Conservation Recovery Program (S)
Allyl chloride	Resource Conservation Recovery Program (NPW)
Allyl chloride	Resource Conservation Recovery Program (S)
Benzene	Resource Conservation Recovery Program (NPW)
Benzene	Resource Conservation Recovery Program (S)
Bromobenzene	Resource Conservation Recovery Program (NPW)
Bromobenzene	Resource Conservation Recovery Program (S)
Bromochloromethane	Resource Conservation Recovery Program (NPW)
Bromochloromethane	Resource Conservation Recovery Program (S)
Bromodichloromethane	Resource Conservation Recovery Program (NPW)
Bromodichloromethane	Resource Conservation Recovery Program (S)
Bromoform	Resource Conservation Recovery Program (NPW)
Bromoform	Resource Conservation Recovery Program (S)
Bromomethane (Methyl bromide)	Resource Conservation Recovery Program (NPW)
Bromomethane (Methyl bromide)	Resource Conservation Recovery Program (S)
Carbon disulfide	Resource Conservation Recovery Program (NPW)
Carbon disulfide	Resource Conservation Recovery Program (S)
Carbon tetrachloride	Resource Conservation Recovery Program (NPW)
Carbon tetrachloride	Resource Conservation Recovery Program (S)
Chlorobenzene	Resource Conservation Recovery Program (NPW)
Chlorobenzene	Resource Conservation Recovery Program (S)
Chloroethane	Resource Conservation Recovery Program (NPW)
Chloroethane	Resource Conservation Recovery Program (S)
Chloroform	Resource Conservation Recovery Program (NPW)
Chloroform	Resource Conservation Recovery Program (S)
Chloroprene	Resource Conservation Recovery Program (NPW)
Chloroprene	Resource Conservation Recovery Program (S)
cis-1,2-Dichloroethylene	Resource Conservation Recovery Program (NPW)
cis-1,2-Dichloroethylene	Resource Conservation Recovery Program (S)
cis-1,3-Dichloropropene	Resource Conservation Recovery Program (NPW)
cis-1,3-Dichloropropene	Resource Conservation Recovery Program (S)
cis-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (NPW)
cis-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (S)
Cyclohexane	Resource Conservation Recovery Program (NPW)
Cyclohexane	Resource Conservation Recovery Program (S)
Dibromochloromethane	Resource Conservation Recovery Program (NPW)
Dibromochloromethane	Resource Conservation Recovery Program (S)
Dibromomethane	Resource Conservation Recovery Program (NPW)
Dibromomethane	Resource Conservation Recovery Program (S)
Dichlorodifluoromethane	Resource Conservation Recovery Program (NPW)
Dichlorodifluoromethane	Resource Conservation Recovery Program (S)
Dichloromethane (Methylene chloride)	Resource Conservation Recovery Program (NPW)
Dichloromethane (Methylene chloride)	Resource Conservation Recovery Program (S)
Diethyl ether	Resource Conservation Recovery Program (NPW)
Diethyl ether	Resource Conservation Recovery Program (S)
Diisopropylether (DIPE)	Resource Conservation Recovery Program (NPW)

Diisopropylether (DIPE)	Resource Conservation Recovery Program (S)
Ethyl methacrylate	Resource Conservation Recovery Program (NPW)
Ethyl methacrylate	Resource Conservation Recovery Program (S)
Ethylbenzene	Resource Conservation Recovery Program (NPW)
Ethylbenzene	Resource Conservation Recovery Program (S)
Freon-113 (Trichlorotrifluoroethane)	Resource Conservation Recovery Program (NPW)
Freon-113 (Trichlorotrifluoroethane)	Resource Conservation Recovery Program (S)
Hexachlorobutadiene	Resource Conservation Recovery Program (NPW)
Hexachlorobutadiene	Resource Conservation Recovery Program (S)
Iodomethane (Methyl iodide)	Resource Conservation Recovery Program (NPW)
Iodomethane (Methyl iodide)	Resource Conservation Recovery Program (S)
Isobutyl alcohol	Resource Conservation Recovery Program (NPW)
Isobutyl alcohol	Resource Conservation Recovery Program (S)
Isopropylbenzene	Resource Conservation Recovery Program (NPW)
Isopropylbenzene	Resource Conservation Recovery Program (S)
Methacrylonitrile	Resource Conservation Recovery Program (NPW)
Methacrylonitrile	Resource Conservation Recovery Program (S)
Methyl acetate	Resource Conservation Recovery Program (NPW)
Methyl acetate	Resource Conservation Recovery Program (S)
Methyl chloride (Chloromethane)	Resource Conservation Recovery Program (NPW)
Methyl chloride (Chloromethane)	Resource Conservation Recovery Program (S)
Methyl isobutyl ketone (MIBK)	Resource Conservation Recovery Program (NPW)
Methyl isobutyl ketone (MIBK)	Resource Conservation Recovery Program (S)
Methyl methacrylate	Resource Conservation Recovery Program (NPW)
Methyl methacrylate	Resource Conservation Recovery Program (S)
Methyl tert-butyl ether (MTBE)	Resource Conservation Recovery Program (NPW)
Methyl tert-butyl ether (MTBE)	Resource Conservation Recovery Program (S)
Methylcyclohexane	Resource Conservation Recovery Program (NPW)
Methylcyclohexane	Resource Conservation Recovery Program (S)
m-Xylene	Resource Conservation Recovery Program (NPW)
m-Xylene	Resource Conservation Recovery Program (S)
Naphthalene	Resource Conservation Recovery Program (NPW)
Naphthalene	Resource Conservation Recovery Program (S)
n-Butylbenzene	Resource Conservation Recovery Program (NPW)
n-Butylbenzene	Resource Conservation Recovery Program (S)
n-Propylbenzene	Resource Conservation Recovery Program (NPW)
n-Propylbenzene	Resource Conservation Recovery Program (S)
Pentachloroethane	Resource Conservation Recovery Program (NPW)
Pentachloroethane	Resource Conservation Recovery Program (S)
p-Isopropyltoluene	Resource Conservation Recovery Program (NPW)
p-Isopropyltoluene	Resource Conservation Recovery Program (S)
Propionitrile (Ethyl cyanide)	Resource Conservation Recovery Program (NPW)
Propionitrile (Ethyl cyanide)	Resource Conservation Recovery Program (S)
p-Xylene	Resource Conservation Recovery Program (NPW)
p-Xylene	Resource Conservation Recovery Program (S)
sec-Butylbenzene	Resource Conservation Recovery Program (NPW)
sec-Butylbenzene	Resource Conservation Recovery Program (S)
Styrene	Resource Conservation Recovery Program (NPW)
Styrene	Resource Conservation Recovery Program (S)
tert-Amyl methyl ether (TAME)	Resource Conservation Recovery Program (NPW)
tert-Amyl methyl ether (TAME)	Resource Conservation Recovery Program (S)
tert-Butyl alcohol	Resource Conservation Recovery Program (NPW)
tert-Butyl alcohol	Resource Conservation Recovery Program (S)
tert-Butylbenzene	Resource Conservation Recovery Program (NPW)
tert-Butylbenzene	Resource Conservation Recovery Program (S)
Tetrachloroethylene	Resource Conservation Recovery Program (NPW)
Tetrachloroethylene	Resource Conservation Recovery Program (S)
Tetrahydrofuran (THF)	Resource Conservation Recovery Program (NPW)
Tetrahydrofuran (THF)	Resource Conservation Recovery Program (S)
Toluene	Resource Conservation Recovery Program (NPW)
Toluene	Resource Conservation Recovery Program (S)
trans-1,2-Dicloroethylene	Resource Conservation Recovery Program (NPW)
trans-1,2-Dicloroethylene	Resource Conservation Recovery Program (S)
trans-1,3-Dichloropropylene	Resource Conservation Recovery Program (NPW)

trans-1,3-Dichloropropylene	Resource Conservation Recovery Program (S)
trans-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (NPW)
trans-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (S)
Trichloroethene (Trichloroethylene)	Resource Conservation Recovery Program (NPW)
Trichloroethene (Trichloroethylene)	Resource Conservation Recovery Program (S)
Trichlorofluoromethane	Resource Conservation Recovery Program (NPW)
Trichlorofluoromethane	Resource Conservation Recovery Program (S)
Vinyl acetate	Resource Conservation Recovery Program (NPW)
Vinyl acetate	Resource Conservation Recovery Program (S)
Vinyl chloride	Resource Conservation Recovery Program (NPW)
Vinyl chloride	Resource Conservation Recovery Program (S)
Xylene (total)	Resource Conservation Recovery Program (NPW)
Xylene (total)	Resource Conservation Recovery Program (S)
EPA 8260C	
1,1,1,2-Tetrachloroethane	Resource Conservation Recovery Program (NPW)
1,1,1,2-Tetrachloroethane	Resource Conservation Recovery Program (S)
1,1,1-Trichloroethane	Resource Conservation Recovery Program (NPW)
1,1,1-Trichloroethane	Resource Conservation Recovery Program (S)
1,1,2,2-Tetrachloroethane	Resource Conservation Recovery Program (NPW)
1,1,2,2-Tetrachloroethane	Resource Conservation Recovery Program (S)
1,1,2-Trichloro-1,2,2-trifluoroethane	Resource Conservation Recovery Program (NPW)
1,1,2-Trichloro-1,2,2-trifluoroethane	Resource Conservation Recovery Program (S)
1,1,2-Trichloroethane	Resource Conservation Recovery Program (NPW)
1,1,2-Trichloroethane	Resource Conservation Recovery Program (S)
1,1-Dichloroethane	Resource Conservation Recovery Program (NPW)
1,1-Dichloroethane	Resource Conservation Recovery Program (S)
1,1-Dichloroethylene	Resource Conservation Recovery Program (NPW)
1,1-Dichloroethylene	Resource Conservation Recovery Program (S)
1,1-Dichloropropene	Resource Conservation Recovery Program (NPW)
1,1-Dichloropropene	Resource Conservation Recovery Program (S)
1,2,3-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,3-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,2,3-Trichloropropane	Resource Conservation Recovery Program (NPW)
1,2,3-Trichloropropane	Resource Conservation Recovery Program (S)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,2,4-Trimethylbenzene	Resource Conservation Recovery Program (NPW)
1,2,4-Trimethylbenzene	Resource Conservation Recovery Program (S)
1,2-Dibromo-3-chloropropane (DBCP)	Resource Conservation Recovery Program (NPW)
1,2-Dibromo-3-chloropropane (DBCP)	Resource Conservation Recovery Program (S)
1,2-Dibromoethane (EDB, Ethylene dibromide)	Resource Conservation Recovery Program (NPW)
1,2-Dibromoethane (EDB, Ethylene dibromide)	Resource Conservation Recovery Program (S)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,2-Dichloroethane	Resource Conservation Recovery Program (NPW)
1,2-Dichloroethane	Resource Conservation Recovery Program (S)
1,2-Dichloropropane	Resource Conservation Recovery Program (NPW)
1,2-Dichloropropane	Resource Conservation Recovery Program (S)
1,3,5-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,3,5-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,3,5-Trimethylbenzene	Resource Conservation Recovery Program (NPW)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,3-Dichloropropane	Resource Conservation Recovery Program (NPW)
1,3-Dichloropropane	Resource Conservation Recovery Program (S)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (NPW)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (S)
1-Chlorohexane	Resource Conservation Recovery Program (NPW)
1-Chlorohexane	Resource Conservation Recovery Program (S)
2,2-Dichloropropane	Resource Conservation Recovery Program (NPW)
2,2-Dichloropropane	Resource Conservation Recovery Program (S)
2-Butanone (Methyl ethyl ketone, MEK)	Resource Conservation Recovery Program (NPW)

2-Butanone (Methyl ethyl ketone, MEK)	Resource Conservation Recovery Program (S)
2-Chloroethyl vinyl ether	Resource Conservation Recovery Program (NPW)
2-Chloroethyl vinyl ether	Resource Conservation Recovery Program (S)
2-Chlorotoluene	Resource Conservation Recovery Program (NPW)
2-Chlorotoluene	Resource Conservation Recovery Program (S)
2-Hexanone	Resource Conservation Recovery Program (NPW)
2-Hexanone	Resource Conservation Recovery Program (S)
4-Chlorotoluene	Resource Conservation Recovery Program (NPW)
4-Chlorotoluene	Resource Conservation Recovery Program (S)
4-Methyl-2-pentanone (MIBK)	Resource Conservation Recovery Program (NPW)
4-Methyl-2-pentanone (MIBK)	Resource Conservation Recovery Program (S)
Acetone	Resource Conservation Recovery Program (NPW)
Acetone	Resource Conservation Recovery Program (S)
Acetonitrile	Resource Conservation Recovery Program (NPW)
Acetonitrile	Resource Conservation Recovery Program (S)
Acrolein	Resource Conservation Recovery Program (NPW)
Acrolein	Resource Conservation Recovery Program (S)
Allyl chloride	Resource Conservation Recovery Program (NPW)
Allyl chloride	Resource Conservation Recovery Program (S)
Benzene	Resource Conservation Recovery Program (NPW)
Benzene	Resource Conservation Recovery Program (S)
Bromobenzene	Resource Conservation Recovery Program (NPW)
Bromobenzene	Resource Conservation Recovery Program (S)
Bromochloromethane	Resource Conservation Recovery Program (NPW)
Bromochloromethane	Resource Conservation Recovery Program (S)
Bromodichloromethane	Resource Conservation Recovery Program (NPW)
Bromodichloromethane	Resource Conservation Recovery Program (S)
Bromoform	Resource Conservation Recovery Program (NPW)
Bromoform	Resource Conservation Recovery Program (S)
Bromomethane (Methyl bromide)	Resource Conservation Recovery Program (NPW)
Bromomethane (Methyl bromide)	Resource Conservation Recovery Program (S)
Carbon disulfide	Resource Conservation Recovery Program (NPW)
Carbon disulfide	Resource Conservation Recovery Program (S)
Carbon tetrachloride	Resource Conservation Recovery Program (NPW)
Carbon tetrachloride	Resource Conservation Recovery Program (S)
Chlorobenzene	Resource Conservation Recovery Program (NPW)
Chlorobenzene	Resource Conservation Recovery Program (S)
Chloroethane	Resource Conservation Recovery Program (NPW)
Chloroethane	Resource Conservation Recovery Program (S)
Chloroform	Resource Conservation Recovery Program (NPW)
Chloroform	Resource Conservation Recovery Program (S)
Chloroprene	Resource Conservation Recovery Program (NPW)
Chloroprene	Resource Conservation Recovery Program (S)
cis-1,2-Dichloroethylene	Resource Conservation Recovery Program (NPW)
cis-1,2-Dichloroethylene	Resource Conservation Recovery Program (S)
cis-1,3-Dichloropropene	Resource Conservation Recovery Program (NPW)
cis-1,3-Dichloropropene	Resource Conservation Recovery Program (S)
cis-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (NPW)
cis-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (S)
Cyclohexane	Resource Conservation Recovery Program (NPW)
Cyclohexane	Resource Conservation Recovery Program (S)
Dibromochloromethane	Resource Conservation Recovery Program (NPW)
Dibromochloromethane	Resource Conservation Recovery Program (S)
Dibromomethane	Resource Conservation Recovery Program (NPW)
Dibromomethane	Resource Conservation Recovery Program (S)
Dichlorodifluoromethane	Resource Conservation Recovery Program (NPW)
Dichlorodifluoromethane	Resource Conservation Recovery Program (S)
Dichloromethane (Methylene chloride)	Resource Conservation Recovery Program (NPW)
Dichloromethane (Methylene chloride)	Resource Conservation Recovery Program (S)
Diethyl ether	Resource Conservation Recovery Program (NPW)
Diethyl ether	Resource Conservation Recovery Program (S)
Diisopropylether (DIPE)	Resource Conservation Recovery Program (NPW)
Diisopropylether (DIPE)	Resource Conservation Recovery Program (S)
Ethyl methacrylate	Resource Conservation Recovery Program (NPW)

Ethyl methacrylate	Resource Conservation Recovery Program (S)
Ethylbenzene	Resource Conservation Recovery Program (NPW)
Ethylbenzene	Resource Conservation Recovery Program (S)
Freon-113 (Trichlorotrifluoroethane)	Resource Conservation Recovery Program (NPW)
Freon-113 (Trichlorotrifluoroethane)	Resource Conservation Recovery Program (S)
Hexachlorobutadiene	Resource Conservation Recovery Program (NPW)
Hexachlorobutadiene	Resource Conservation Recovery Program (S)
Iodomethane (Methyl iodide)	Resource Conservation Recovery Program (NPW)
Iodomethane (Methyl iodide)	Resource Conservation Recovery Program (S)
Isobutyl alcohol	Resource Conservation Recovery Program (NPW)
Isobutyl alcohol	Resource Conservation Recovery Program (S)
Isopropylbenzene	Resource Conservation Recovery Program (NPW)
Isopropylbenzene	Resource Conservation Recovery Program (S)
Methacrylonitrile	Resource Conservation Recovery Program (NPW)
Methacrylonitrile	Resource Conservation Recovery Program (S)
Methyl acetate	Resource Conservation Recovery Program (NPW)
Methyl acetate	Resource Conservation Recovery Program (S)
Methyl chloride (Chloromethane)	Resource Conservation Recovery Program (NPW)
Methyl chloride (Chloromethane)	Resource Conservation Recovery Program (S)
Methyl isobutyl ketone (MIBK)	Resource Conservation Recovery Program (NPW)
Methyl isobutyl ketone (MIBK)	Resource Conservation Recovery Program (S)
Methyl methacrylate	Resource Conservation Recovery Program (NPW)
Methyl methacrylate	Resource Conservation Recovery Program (S)
Methyl tert-butyl ether (MTBE)	Resource Conservation Recovery Program (NPW)
Methyl tert-butyl ether (MTBE)	Resource Conservation Recovery Program (S)
Methylcyclohexane	Resource Conservation Recovery Program (NPW)
Methylcyclohexane	Resource Conservation Recovery Program (S)
m-Xylene	Resource Conservation Recovery Program (NPW)
m-Xylene	Resource Conservation Recovery Program (S)
Naphthalene	Resource Conservation Recovery Program (NPW)
Naphthalene	Resource Conservation Recovery Program (S)
n-Butylbenzene	Resource Conservation Recovery Program (NPW)
n-Butylbenzene	Resource Conservation Recovery Program (S)
n-Propylbenzene	Resource Conservation Recovery Program (NPW)
n-Propylbenzene	Resource Conservation Recovery Program (S)
Pentachloroethane	Resource Conservation Recovery Program (NPW)
Pentachloroethane	Resource Conservation Recovery Program (S)
p-Isopropyltoluene	Resource Conservation Recovery Program (NPW)
p-Isopropyltoluene	Resource Conservation Recovery Program (S)
Propionitrile (Ethyl cyanide)	Resource Conservation Recovery Program (NPW)
Propionitrile (Ethyl cyanide)	Resource Conservation Recovery Program (S)
p-Xylene	Resource Conservation Recovery Program (NPW)
p-Xylene	Resource Conservation Recovery Program (S)
sec-Butylbenzene	Resource Conservation Recovery Program (NPW)
sec-Butylbenzene	Resource Conservation Recovery Program (S)
Styrene	Resource Conservation Recovery Program (NPW)
Styrene	Resource Conservation Recovery Program (S)
tert-Amyl methyl ether (TAME)	Resource Conservation Recovery Program (NPW)
tert-Amyl methyl ether (TAME)	Resource Conservation Recovery Program (S)
tert-Butyl alcohol	Resource Conservation Recovery Program (NPW)
tert-Butyl alcohol	Resource Conservation Recovery Program (S)
tert-Butylbenzene	Resource Conservation Recovery Program (NPW)
tert-Butylbenzene	Resource Conservation Recovery Program (S)
Tetrachloroethylene	Resource Conservation Recovery Program (NPW)
Tetrachloroethylene	Resource Conservation Recovery Program (S)
Tetrahydrofuran (THF)	Resource Conservation Recovery Program (NPW)
Tetrahydrofuran (THF)	Resource Conservation Recovery Program (S)
Toluene	Resource Conservation Recovery Program (NPW)
Toluene	Resource Conservation Recovery Program (S)
trans-1,2-Dicloroethylene	Resource Conservation Recovery Program (NPW)
trans-1,2-Dicloroethylene	Resource Conservation Recovery Program (S)
trans-1,3-Dichloropropylene	Resource Conservation Recovery Program (NPW)
trans-1,3-Dichloropropylene	Resource Conservation Recovery Program (S)
trans-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (NPW)

trans-1,4-Dichloro-2-butene	Resource Conservation Recovery Program (S)
Trichloroethene (Trichloroethylene)	Resource Conservation Recovery Program (NPW)
Trichloroethene (Trichloroethylene)	Resource Conservation Recovery Program (S)
Trichlorofluoromethane	Resource Conservation Recovery Program (NPW)
Trichlorofluoromethane	Resource Conservation Recovery Program (S)
Vinyl acetate	Resource Conservation Recovery Program (NPW)
Vinyl acetate	Resource Conservation Recovery Program (S)
Vinyl chloride	Resource Conservation Recovery Program (NPW)
Vinyl chloride	Resource Conservation Recovery Program (S)
Xylene (total)	Resource Conservation Recovery Program (NPW)
Xylene (total)	Resource Conservation Recovery Program (S)
EPA 8270C	
1,1'-Biphenyl	Resource Conservation Recovery Program (NPW)
1,1'-Biphenyl	Resource Conservation Recovery Program (S)
1,2,4,5-Tetrachlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,4,5-Tetrachlorobenzene	Resource Conservation Recovery Program (S)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,2-Diphenylhydrazine	Resource Conservation Recovery Program (NPW)
1,2-Diphenylhydrazine	Resource Conservation Recovery Program (S)
1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (NPW)
1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (S)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (NPW)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (S)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (NPW)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (S)
1,4-Naphthoquinone	Resource Conservation Recovery Program (NPW)
1,4-Naphthoquinone	Resource Conservation Recovery Program (S)
1-Chloronaphthalene	Resource Conservation Recovery Program (NPW)
1-Chloronaphthalene	Resource Conservation Recovery Program (S)
1-Methylnaphthalene	Resource Conservation Recovery Program (NPW)
1-Methylnaphthalene	Resource Conservation Recovery Program (S)
1-Naphthylamine	Resource Conservation Recovery Program (NPW)
1-Naphthylamine	Resource Conservation Recovery Program (S)
2,2'-Oxybis(1-chloropropane)	Resource Conservation Recovery Program (NPW)
2,2'-Oxybis(1-chloropropane)	Resource Conservation Recovery Program (S)
2,3,4,6-Tetrachlorophenol	Resource Conservation Recovery Program (NPW)
2,3,4,6-Tetrachlorophenol	Resource Conservation Recovery Program (S)
2,4,5-Trichlorophenol	Resource Conservation Recovery Program (NPW)
2,4,5-Trichlorophenol	Resource Conservation Recovery Program (S)
2,4,6-Trichlorophenol	Resource Conservation Recovery Program (NPW)
2,4,6-Trichlorophenol	Resource Conservation Recovery Program (S)
2,4-Dichlorophenol	Resource Conservation Recovery Program (NPW)
2,4-Dichlorophenol	Resource Conservation Recovery Program (S)
2,4-Dimethylphenol	Resource Conservation Recovery Program (NPW)
2,4-Dimethylphenol	Resource Conservation Recovery Program (S)
2,4-Dinitrophenol	Resource Conservation Recovery Program (NPW)
2,4-Dinitrophenol	Resource Conservation Recovery Program (S)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (NPW)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (S)
2,6-Dichlorophenol	Resource Conservation Recovery Program (NPW)
2,6-Dichlorophenol	Resource Conservation Recovery Program (S)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (NPW)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (S)
2-Acetylaminofluorene	Resource Conservation Recovery Program (NPW)
2-Acetylaminofluorene	Resource Conservation Recovery Program (S)
2-Chloronaphthalene	Resource Conservation Recovery Program (NPW)
2-Chloronaphthalene	Resource Conservation Recovery Program (S)

2-Chlorophenol	Resource Conservation Recovery Program (NPW)
2-Chlorophenol	Resource Conservation Recovery Program (S)
2-Methylnaphthalene	Resource Conservation Recovery Program (NPW)
2-Methylnaphthalene	Resource Conservation Recovery Program (S)
2-Methylphenol (o-Cresol)	Resource Conservation Recovery Program (NPW)
2-Methylphenol (o-Cresol)	Resource Conservation Recovery Program (S)
2-Naphthylamine	Resource Conservation Recovery Program (NPW)
2-Naphthylamine	Resource Conservation Recovery Program (S)
2-Nitroaniline	Resource Conservation Recovery Program (NPW)
2-Nitroaniline	Resource Conservation Recovery Program (S)
2-Nitrophenol	Resource Conservation Recovery Program (NPW)
2-Nitrophenol	Resource Conservation Recovery Program (S)
2-Picoline (2-Methylpyridine)	Resource Conservation Recovery Program (NPW)
2-Picoline (2-Methylpyridine)	Resource Conservation Recovery Program (S)
3 & 4 Methylphenol	Resource Conservation Recovery Program (NPW)
3,3'-Dichlorobenzidine	Resource Conservation Recovery Program (NPW)
3,3'-Dichlorobenzidine	Resource Conservation Recovery Program (S)
3,3'-Dimethylbenzidine	Resource Conservation Recovery Program (NPW)
3,3'-Dimethylbenzidine	Resource Conservation Recovery Program (S)
3-Methylcholanthrene	Resource Conservation Recovery Program (NPW)
3-Methylcholanthrene	Resource Conservation Recovery Program (S)
3-Nitroaniline	Resource Conservation Recovery Program (NPW)
3-Nitroaniline	Resource Conservation Recovery Program (S)
4,6-Dinitro-2-methylphenol	Resource Conservation Recovery Program (NPW)
4,6-Dinitro-2-methylphenol	Resource Conservation Recovery Program (S)
4-Aminobiphenyl	Resource Conservation Recovery Program (NPW)
4-Aminobiphenyl	Resource Conservation Recovery Program (S)
4-Bromophenyl phenyl ether	Resource Conservation Recovery Program (NPW)
4-Bromophenyl phenyl ether	Resource Conservation Recovery Program (S)
4-Chloro-3-methylphenol	Resource Conservation Recovery Program (NPW)
4-Chloro-3-methylphenol	Resource Conservation Recovery Program (S)
4-Chloroaniline	Resource Conservation Recovery Program (NPW)
4-Chloroaniline	Resource Conservation Recovery Program (S)
4-Chlorophenyl phenylether	Resource Conservation Recovery Program (NPW)
4-Chlorophenyl phenylether	Resource Conservation Recovery Program (S)
4-Nitroaniline	Resource Conservation Recovery Program (NPW)
4-Nitroaniline	Resource Conservation Recovery Program (S)
4-Nitrophenol	Resource Conservation Recovery Program (NPW)
4-Nitrophenol	Resource Conservation Recovery Program (S)
4-Nitroquinoline 1-oxide	Resource Conservation Recovery Program (NPW)
4-Nitroquinoline 1-oxide	Resource Conservation Recovery Program (S)
5-Nitro-o-toluidine	Resource Conservation Recovery Program (NPW)
5-Nitro-o-toluidine	Resource Conservation Recovery Program (S)
7,12-Dimethylbenz[a]anthracene	Resource Conservation Recovery Program (NPW)
7,12-Dimethylbenz[a]anthracene	Resource Conservation Recovery Program (S)
a-a-Dimethylphenethylamine	Resource Conservation Recovery Program (NPW)
a-a-Dimethylphenethylamine	Resource Conservation Recovery Program (S)
Acenaphthene	Resource Conservation Recovery Program (NPW)
Acenaphthene	Resource Conservation Recovery Program (S)
Acenaphthylene	Resource Conservation Recovery Program (NPW)
Acenaphthylene	Resource Conservation Recovery Program (S)
Acetophenone	Resource Conservation Recovery Program (NPW)
Acetophenone	Resource Conservation Recovery Program (S)
Aniline	Resource Conservation Recovery Program (NPW)
Aniline	Resource Conservation Recovery Program (S)
Anthracene	Resource Conservation Recovery Program (NPW)
Anthracene	Resource Conservation Recovery Program (S)
Aramite	Resource Conservation Recovery Program (NPW)
Aramite	Resource Conservation Recovery Program (S)
Atrazine	Resource Conservation Recovery Program (NPW)
Atrazine	Resource Conservation Recovery Program (S)
Azobenzene	Resource Conservation Recovery Program (NPW)
Azobenzene	Resource Conservation Recovery Program (S)
Benzaldehyde	Resource Conservation Recovery Program (NPW)

Benzaldehyde	Resource Conservation Recovery Program (S)
Benzidine	Resource Conservation Recovery Program (NPW)
Benzidine	Resource Conservation Recovery Program (S)
Benzo[a]anthracene	Resource Conservation Recovery Program (NPW)
Benzo[a]anthracene	Resource Conservation Recovery Program (S)
Benzo[a]pyrene	Resource Conservation Recovery Program (NPW)
Benzo[a]pyrene	Resource Conservation Recovery Program (S)
Benzo[b]fluoranthene	Resource Conservation Recovery Program (NPW)
Benzo[b]fluoranthene	Resource Conservation Recovery Program (S)
Benzo[g,h,i]perylene	Resource Conservation Recovery Program (NPW)
Benzo[g,h,i]perylene	Resource Conservation Recovery Program (S)
Benzo[k]fluoranthene	Resource Conservation Recovery Program (NPW)
Benzo[k]fluoranthene	Resource Conservation Recovery Program (S)
Benzoic acid	Resource Conservation Recovery Program (NPW)
Benzoic acid	Resource Conservation Recovery Program (S)
Benzyl alcohol	Resource Conservation Recovery Program (NPW)
Benzyl alcohol	Resource Conservation Recovery Program (S)
bis(2-Chloroethoxy)methane	Resource Conservation Recovery Program (NPW)
bis(2-Chloroethoxy)methane	Resource Conservation Recovery Program (S)
bis(2-Chloroethyl)ether	Resource Conservation Recovery Program (NPW)
bis(2-Chloroethyl)ether	Resource Conservation Recovery Program (S)
bis(2-Ethylhexyl)adipate	Resource Conservation Recovery Program (NPW)
bis(2-Ethylhexyl)adipate	Resource Conservation Recovery Program (S)
bis(2-Ethylhexyl)phthalate (DEHP)	Resource Conservation Recovery Program (NPW)
bis(2-Ethylhexyl)phthalate (DEHP)	Resource Conservation Recovery Program (S)
Butyl benzyl phthalate	Resource Conservation Recovery Program (NPW)
Butyl benzyl phthalate	Resource Conservation Recovery Program (S)
Caprolactam	Resource Conservation Recovery Program (NPW)
Caprolactam	Resource Conservation Recovery Program (S)
Carbazole	Resource Conservation Recovery Program (NPW)
Carbazole	Resource Conservation Recovery Program (S)
Chlorobenzilate	Resource Conservation Recovery Program (NPW)
Chlorobenzilate	Resource Conservation Recovery Program (S)
Chrysene	Resource Conservation Recovery Program (NPW)
Chrysene	Resource Conservation Recovery Program (S)
Diallate	Resource Conservation Recovery Program (NPW)
Diallate	Resource Conservation Recovery Program (S)
Dibenz[a,h]anthracene	Resource Conservation Recovery Program (NPW)
Dibenz[a,h]anthracene	Resource Conservation Recovery Program (S)
Dibenz[a,j]acridine	Resource Conservation Recovery Program (NPW)
Dibenz[a,j]acridine	Resource Conservation Recovery Program (S)
Dibenzofuran	Resource Conservation Recovery Program (NPW)
Dibenzofuran	Resource Conservation Recovery Program (S)
Diethyl phthalate	Resource Conservation Recovery Program (NPW)
Diethyl phthalate	Resource Conservation Recovery Program (S)
Dimethoate	Resource Conservation Recovery Program (NPW)
Dimethoate	Resource Conservation Recovery Program (S)
Dimethyl phthalate	Resource Conservation Recovery Program (NPW)
Dimethyl phthalate	Resource Conservation Recovery Program (S)
Di-n-butyl phthalate	Resource Conservation Recovery Program (NPW)
Di-n-butyl phthalate	Resource Conservation Recovery Program (S)
Di-n-octyl phthalate	Resource Conservation Recovery Program (NPW)
Di-n-octyl phthalate	Resource Conservation Recovery Program (S)
Dinoseb	Resource Conservation Recovery Program (NPW)
Dinoseb	Resource Conservation Recovery Program (S)
Disulfoton	Resource Conservation Recovery Program (NPW)
Disulfoton	Resource Conservation Recovery Program (S)
Ethyl methanesulfonate	Resource Conservation Recovery Program (NPW)
Ethyl methanesulfonate	Resource Conservation Recovery Program (S)
Famphur	Resource Conservation Recovery Program (NPW)
Famphur	Resource Conservation Recovery Program (S)
Fluoranthene	Resource Conservation Recovery Program (NPW)
Fluoranthene	Resource Conservation Recovery Program (S)
Fluorene	Resource Conservation Recovery Program (NPW)

Fluorene	Resource Conservation Recovery Program (S)
Hexachlorobenzene	Resource Conservation Recovery Program (NPW)
Hexachlorobenzene	Resource Conservation Recovery Program (S)
Hexachlorobutadiene	Resource Conservation Recovery Program (NPW)
Hexachlorobutadiene	Resource Conservation Recovery Program (S)
Hexachlorocyclopentadiene	Resource Conservation Recovery Program (NPW)
Hexachlorocyclopentadiene	Resource Conservation Recovery Program (S)
Hexachloroethane	Resource Conservation Recovery Program (NPW)
Hexachloroethane	Resource Conservation Recovery Program (S)
Hexachlorophene	Resource Conservation Recovery Program (NPW)
Hexachlorophene	Resource Conservation Recovery Program (S)
Hexachloropropene	Resource Conservation Recovery Program (NPW)
Hexachloropropene	Resource Conservation Recovery Program (S)
Indeno[1,2,3-cd]pyrene	Resource Conservation Recovery Program (NPW)
Indeno[1,2,3-cd]pyrene	Resource Conservation Recovery Program (S)
Isodrin	Resource Conservation Recovery Program (NPW)
Isodrin	Resource Conservation Recovery Program (S)
Isophorone	Resource Conservation Recovery Program (NPW)
Isophorone	Resource Conservation Recovery Program (S)
Isosafrole	Resource Conservation Recovery Program (NPW)
Isosafrole	Resource Conservation Recovery Program (S)
Kepone	Resource Conservation Recovery Program (NPW)
Kepone	Resource Conservation Recovery Program (S)
Methapyrilene	Resource Conservation Recovery Program (NPW)
Methapyrilene	Resource Conservation Recovery Program (S)
Methyl methanesulfonate	Resource Conservation Recovery Program (NPW)
Methyl methanesulfonate	Resource Conservation Recovery Program (S)
Methyl parathion	Resource Conservation Recovery Program (NPW)
Methyl parathion	Resource Conservation Recovery Program (S)
Naphthalene	Resource Conservation Recovery Program (NPW)
Naphthalene	Resource Conservation Recovery Program (S)
Nitrobenzene	Resource Conservation Recovery Program (NPW)
Nitrobenzene	Resource Conservation Recovery Program (S)
n-Nitrosodiethylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosodiethylamine	Resource Conservation Recovery Program (S)
n-Nitrosodimethylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosodimethylamine	Resource Conservation Recovery Program (S)
n-Nitroso-di-n-butylamine	Resource Conservation Recovery Program (NPW)
n-Nitroso-di-n-butylamine	Resource Conservation Recovery Program (S)
n-Nitroso-di-n-propylamine	Resource Conservation Recovery Program (NPW)
n-Nitroso-di-n-propylamine	Resource Conservation Recovery Program (S)
n-Nitrosodiphenylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosodiphenylamine	Resource Conservation Recovery Program (S)
n-Nitrosomethylethylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosomethylethylamine	Resource Conservation Recovery Program (S)
n-Nitrosomorpholine	Resource Conservation Recovery Program (NPW)
n-Nitrosomorpholine	Resource Conservation Recovery Program (S)
n-Nitrosopiperidine	Resource Conservation Recovery Program (NPW)
n-Nitrosopiperidine	Resource Conservation Recovery Program (S)
n-Nitrosopyrrolidine	Resource Conservation Recovery Program (NPW)
n-Nitrosopyrrolidine	Resource Conservation Recovery Program (S)
o,o,o-Triethyl phosphorothioate	Resource Conservation Recovery Program (NPW)
o,o,o-Triethyl phosphorothioate	Resource Conservation Recovery Program (S)
o-Toluidine	Resource Conservation Recovery Program (NPW)
o-Toluidine	Resource Conservation Recovery Program (S)
Parathion	Resource Conservation Recovery Program (NPW)
Parathion	Resource Conservation Recovery Program (S)
Pentachlorobenzene	Resource Conservation Recovery Program (NPW)
Pentachlorobenzene	Resource Conservation Recovery Program (S)
Pentachloronitrobenzene	Resource Conservation Recovery Program (NPW)
Pentachloronitrobenzene	Resource Conservation Recovery Program (S)
Pentachlorophenol	Resource Conservation Recovery Program (NPW)
Pentachlorophenol	Resource Conservation Recovery Program (S)
Phenacetin	Resource Conservation Recovery Program (NPW)

Phenacetin	Resource Conservation Recovery Program (S)
Phenanthrene	Resource Conservation Recovery Program (NPW)
Phenanthrene	Resource Conservation Recovery Program (S)
Phenol	Resource Conservation Recovery Program (NPW)
Phenol	Resource Conservation Recovery Program (S)
Phorate	Resource Conservation Recovery Program (NPW)
Phorate	Resource Conservation Recovery Program (S)
p-Phenylenediamine	Resource Conservation Recovery Program (NPW)
p-Phenylenediamine	Resource Conservation Recovery Program (S)
Pronamide (Kerb)	Resource Conservation Recovery Program (NPW)
Pronamide (Kerb)	Resource Conservation Recovery Program (S)
Pyrene	Resource Conservation Recovery Program (NPW)
Pyrene	Resource Conservation Recovery Program (S)
Pyridine	Resource Conservation Recovery Program (NPW)
Pyridine	Resource Conservation Recovery Program (S)
Safrole	Resource Conservation Recovery Program (NPW)
Safrole	Resource Conservation Recovery Program (S)
Sulfotepp	Resource Conservation Recovery Program (NPW)
Sulfotepp	Resource Conservation Recovery Program (S)
EPA 8270D	
1,1'-Biphenyl	Resource Conservation Recovery Program (NPW)
1,1'-Biphenyl	Resource Conservation Recovery Program (S)
1,2,4,5-Tetrachlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,4,5-Tetrachlorobenzene	Resource Conservation Recovery Program (S)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2,4-Trichlorobenzene	Resource Conservation Recovery Program (S)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,2-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,2-Diphenylhydrazine	Resource Conservation Recovery Program (NPW)
1,2-Diphenylhydrazine	Resource Conservation Recovery Program (S)
1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (NPW)
1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (S)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,3-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (NPW)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (S)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (NPW)
1,4-Dichlorobenzene	Resource Conservation Recovery Program (S)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (NPW)
1,4-Dioxane (1,4- Diethyleneoxide)	Resource Conservation Recovery Program (S)
1,4-Naphthoquinone	Resource Conservation Recovery Program (NPW)
1,4-Naphthoquinone	Resource Conservation Recovery Program (S)
1-Chloronaphthalene	Resource Conservation Recovery Program (NPW)
1-Chloronaphthalene	Resource Conservation Recovery Program (S)
1-Methylnaphthalene	Resource Conservation Recovery Program (NPW)
1-Methylnaphthalene	Resource Conservation Recovery Program (S)
1-Naphthylamine	Resource Conservation Recovery Program (NPW)
1-Naphthylamine	Resource Conservation Recovery Program (S)
2,2'-Oxybis(1-chloropropane)	Resource Conservation Recovery Program (NPW)
2,2'-Oxybis(1-chloropropane)	Resource Conservation Recovery Program (S)
2,3,4,6-Tetrachlorophenol	Resource Conservation Recovery Program (NPW)
2,3,4,6-Tetrachlorophenol	Resource Conservation Recovery Program (S)
2,4,5-Trichlorophenol	Resource Conservation Recovery Program (NPW)
2,4,5-Trichlorophenol	Resource Conservation Recovery Program (S)
2,4,6-Trichlorophenol	Resource Conservation Recovery Program (NPW)
2,4,6-Trichlorophenol	Resource Conservation Recovery Program (S)
2,4-Dichlorophenol	Resource Conservation Recovery Program (NPW)
2,4-Dichlorophenol	Resource Conservation Recovery Program (S)
2,4-Dimethylphenol	Resource Conservation Recovery Program (NPW)
2,4-Dimethylphenol	Resource Conservation Recovery Program (S)
2,4-Dinitrophenol	Resource Conservation Recovery Program (NPW)
2,4-Dinitrophenol	Resource Conservation Recovery Program (S)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (NPW)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (S)

2,6-Dichlorophenol	Resource Conservation Recovery Program (NPW)
2,6-Dichlorophenol	Resource Conservation Recovery Program (S)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (NPW)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (S)
2-Acetylaminofluorene	Resource Conservation Recovery Program (NPW)
2-Acetylaminofluorene	Resource Conservation Recovery Program (S)
2-Chloronaphthalene	Resource Conservation Recovery Program (NPW)
2-Chloronaphthalene	Resource Conservation Recovery Program (S)
2-Chlorophenol	Resource Conservation Recovery Program (NPW)
2-Chlorophenol	Resource Conservation Recovery Program (S)
2-Methylnaphthalene	Resource Conservation Recovery Program (NPW)
2-Methylnaphthalene	Resource Conservation Recovery Program (S)
2-Methylphenol (o-Cresol)	Resource Conservation Recovery Program (NPW)
2-Methylphenol (o-Cresol)	Resource Conservation Recovery Program (S)
2-Naphthylamine	Resource Conservation Recovery Program (NPW)
2-Naphthylamine	Resource Conservation Recovery Program (S)
2-Nitroaniline	Resource Conservation Recovery Program (NPW)
2-Nitroaniline	Resource Conservation Recovery Program (S)
2-Nitrophenol	Resource Conservation Recovery Program (NPW)
2-Nitrophenol	Resource Conservation Recovery Program (S)
2-Picoline (2-Methylpyridine)	Resource Conservation Recovery Program (NPW)
2-Picoline (2-Methylpyridine)	Resource Conservation Recovery Program (S)
3 & 4 Methylphenol	Resource Conservation Recovery Program (NPW)
3,3'-Dichlorobenzidine	Resource Conservation Recovery Program (NPW)
3,3'-Dichlorobenzidine	Resource Conservation Recovery Program (S)
3,3'-Dimethylbenzidine	Resource Conservation Recovery Program (NPW)
3,3'-Dimethylbenzidine	Resource Conservation Recovery Program (S)
3-Methylcholanthrene	Resource Conservation Recovery Program (NPW)
3-Methylcholanthrene	Resource Conservation Recovery Program (S)
3-Nitroaniline	Resource Conservation Recovery Program (NPW)
3-Nitroaniline	Resource Conservation Recovery Program (S)
4,6-Dinitro-2-methylphenol	Resource Conservation Recovery Program (NPW)
4,6-Dinitro-2-methylphenol	Resource Conservation Recovery Program (S)
4-Aminobiphenyl	Resource Conservation Recovery Program (NPW)
4-Aminobiphenyl	Resource Conservation Recovery Program (S)
4-Bromophenyl phenyl ether	Resource Conservation Recovery Program (NPW)
4-Bromophenyl phenyl ether	Resource Conservation Recovery Program (S)
4-Chloro-3-methylphenol	Resource Conservation Recovery Program (NPW)
4-Chloro-3-methylphenol	Resource Conservation Recovery Program (S)
4-Chloroaniline	Resource Conservation Recovery Program (NPW)
4-Chloroaniline	Resource Conservation Recovery Program (S)
4-Chlorophenyl phenylether	Resource Conservation Recovery Program (NPW)
4-Chlorophenyl phenylether	Resource Conservation Recovery Program (S)
4-Nitroaniline	Resource Conservation Recovery Program (NPW)
4-Nitroaniline	Resource Conservation Recovery Program (S)
4-Nitrophenol	Resource Conservation Recovery Program (NPW)
4-Nitrophenol	Resource Conservation Recovery Program (S)
4-Nitroquinoline 1-oxide	Resource Conservation Recovery Program (NPW)
4-Nitroquinoline 1-oxide	Resource Conservation Recovery Program (S)
5-Nitro-o-toluidine	Resource Conservation Recovery Program (NPW)
5-Nitro-o-toluidine	Resource Conservation Recovery Program (S)
7,12-Dimethylbenz[a]anthracene	Resource Conservation Recovery Program (NPW)
7,12-Dimethylbenz[a]anthracene	Resource Conservation Recovery Program (S)
a-a-Dimethylphenethylamine	Resource Conservation Recovery Program (NPW)
a-a-Dimethylphenethylamine	Resource Conservation Recovery Program (S)
Acenaphthene	Resource Conservation Recovery Program (NPW)
Acenaphthene	Resource Conservation Recovery Program (S)
Acenaphthylene	Resource Conservation Recovery Program (NPW)
Acenaphthylene	Resource Conservation Recovery Program (S)
Acetophenone	Resource Conservation Recovery Program (NPW)
Acetophenone	Resource Conservation Recovery Program (S)
Aniline	Resource Conservation Recovery Program (NPW)
Aniline	Resource Conservation Recovery Program (S)
Anthracene	Resource Conservation Recovery Program (NPW)

Anthracene	Resource Conservation Recovery Program (S)
Aramite	Resource Conservation Recovery Program (NPW)
Aramite	Resource Conservation Recovery Program (S)
Atrazine	Resource Conservation Recovery Program (NPW)
Atrazine	Resource Conservation Recovery Program (S)
Azobenzene	Resource Conservation Recovery Program (NPW)
Azobenzene	Resource Conservation Recovery Program (S)
Benzaldehyde	Resource Conservation Recovery Program (NPW)
Benzaldehyde	Resource Conservation Recovery Program (S)
Benzidine	Resource Conservation Recovery Program (NPW)
Benzidine	Resource Conservation Recovery Program (S)
Benzo[a]anthracene	Resource Conservation Recovery Program (NPW)
Benzo[a]anthracene	Resource Conservation Recovery Program (S)
Benzo[a]pyrene	Resource Conservation Recovery Program (NPW)
Benzo[a]pyrene	Resource Conservation Recovery Program (S)
Benzo[b]fluoranthene	Resource Conservation Recovery Program (NPW)
Benzo[b]fluoranthene	Resource Conservation Recovery Program (S)
Benzo[g,h,i]perylene	Resource Conservation Recovery Program (NPW)
Benzo[g,h,i]perylene	Resource Conservation Recovery Program (S)
Benzo[k]fluoranthene	Resource Conservation Recovery Program (NPW)
Benzo[k]fluoranthene	Resource Conservation Recovery Program (S)
Benzoic acid	Resource Conservation Recovery Program (NPW)
Benzoic acid	Resource Conservation Recovery Program (S)
Benzyl alcohol	Resource Conservation Recovery Program (NPW)
Benzyl alcohol	Resource Conservation Recovery Program (S)
bis(2-Chloroethoxy)methane	Resource Conservation Recovery Program (NPW)
bis(2-Chloroethoxy)methane	Resource Conservation Recovery Program (S)
bis(2-Chloroethyl)ether	Resource Conservation Recovery Program (NPW)
bis(2-Chloroethyl)ether	Resource Conservation Recovery Program (S)
bis(2-Ethylhexyl)adipate	Resource Conservation Recovery Program (NPW)
bis(2-Ethylhexyl)adipate	Resource Conservation Recovery Program (S)
bis(2-Ethylhexyl)phthalate (DEHP)	Resource Conservation Recovery Program (NPW)
bis(2-Ethylhexyl)phthalate (DEHP)	Resource Conservation Recovery Program (S)
Butyl benzyl phthalate	Resource Conservation Recovery Program (NPW)
Butyl benzyl phthalate	Resource Conservation Recovery Program (S)
Caprolactam	Resource Conservation Recovery Program (NPW)
Caprolactam	Resource Conservation Recovery Program (S)
Carbazole	Resource Conservation Recovery Program (NPW)
Carbazole	Resource Conservation Recovery Program (S)
Chlorobenzilate	Resource Conservation Recovery Program (NPW)
Chlorobenzilate	Resource Conservation Recovery Program (S)
Chrysene	Resource Conservation Recovery Program (NPW)
Chrysene	Resource Conservation Recovery Program (S)
Diallate	Resource Conservation Recovery Program (NPW)
Diallate	Resource Conservation Recovery Program (S)
Dibenz[a,h]anthracene	Resource Conservation Recovery Program (NPW)
Dibenz[a,h]anthracene	Resource Conservation Recovery Program (S)
Dibenz[a,j]acridine	Resource Conservation Recovery Program (NPW)
Dibenz[a,j]acridine	Resource Conservation Recovery Program (S)
Dibenzofuran	Resource Conservation Recovery Program (NPW)
Dibenzofuran	Resource Conservation Recovery Program (S)
Diethyl phthalate	Resource Conservation Recovery Program (NPW)
Diethyl phthalate	Resource Conservation Recovery Program (S)
Dimethoate	Resource Conservation Recovery Program (NPW)
Dimethoate	Resource Conservation Recovery Program (S)
Dimethyl phthalate	Resource Conservation Recovery Program (NPW)
Dimethyl phthalate	Resource Conservation Recovery Program (S)
Di-n-butyl phthalate	Resource Conservation Recovery Program (NPW)
Di-n-butyl phthalate	Resource Conservation Recovery Program (S)
Di-n-octyl phthalate	Resource Conservation Recovery Program (NPW)
Di-n-octyl phthalate	Resource Conservation Recovery Program (S)
Dinoseb	Resource Conservation Recovery Program (NPW)
Dinoseb	Resource Conservation Recovery Program (S)
Disulfoton	Resource Conservation Recovery Program (NPW)

Disulfoton	Resource Conservation Recovery Program (S)
Ethyl methanesulfonate	Resource Conservation Recovery Program (NPW)
Ethyl methanesulfonate	Resource Conservation Recovery Program (S)
Famphur	Resource Conservation Recovery Program (NPW)
Famphur	Resource Conservation Recovery Program (S)
Fluoranthene	Resource Conservation Recovery Program (NPW)
Fluoranthene	Resource Conservation Recovery Program (S)
Fluorene	Resource Conservation Recovery Program (NPW)
Fluorene	Resource Conservation Recovery Program (S)
Hexachlorobenzene	Resource Conservation Recovery Program (NPW)
Hexachlorobenzene	Resource Conservation Recovery Program (S)
Hexachlorobutadiene	Resource Conservation Recovery Program (NPW)
Hexachlorobutadiene	Resource Conservation Recovery Program (S)
Hexachlorocyclopentadiene	Resource Conservation Recovery Program (NPW)
Hexachlorocyclopentadiene	Resource Conservation Recovery Program (S)
Hexachloroethane	Resource Conservation Recovery Program (NPW)
Hexachloroethane	Resource Conservation Recovery Program (S)
Hexachlorophene	Resource Conservation Recovery Program (NPW)
Hexachlorophene	Resource Conservation Recovery Program (S)
Hexachloropropene	Resource Conservation Recovery Program (NPW)
Hexachloropropene	Resource Conservation Recovery Program (S)
Indeno[1,2,3-cd]pyrene	Resource Conservation Recovery Program (NPW)
Indeno[1,2,3-cd]pyrene	Resource Conservation Recovery Program (S)
Isodrin	Resource Conservation Recovery Program (NPW)
Isodrin	Resource Conservation Recovery Program (S)
Isophorone	Resource Conservation Recovery Program (NPW)
Isophorone	Resource Conservation Recovery Program (S)
Isosafrole	Resource Conservation Recovery Program (NPW)
Isosafrole	Resource Conservation Recovery Program (S)
Kepone	Resource Conservation Recovery Program (NPW)
Kepone	Resource Conservation Recovery Program (S)
Methapyrilene	Resource Conservation Recovery Program (NPW)
Methapyrilene	Resource Conservation Recovery Program (S)
Methyl methanesulfonate	Resource Conservation Recovery Program (NPW)
Methyl methanesulfonate	Resource Conservation Recovery Program (S)
Methyl parathion	Resource Conservation Recovery Program (NPW)
Methyl parathion	Resource Conservation Recovery Program (S)
Naphthalene	Resource Conservation Recovery Program (NPW)
Naphthalene	Resource Conservation Recovery Program (S)
Nitrobenzene	Resource Conservation Recovery Program (NPW)
Nitrobenzene	Resource Conservation Recovery Program (S)
n-Nitrosodiethylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosodiethylamine	Resource Conservation Recovery Program (S)
n-Nitrosodimethylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosodimethylamine	Resource Conservation Recovery Program (S)
n-Nitroso-di-n-butylamine	Resource Conservation Recovery Program (NPW)
n-Nitroso-di-n-butylamine	Resource Conservation Recovery Program (S)
n-Nitroso-di-n-propylamine	Resource Conservation Recovery Program (NPW)
n-Nitroso-di-n-propylamine	Resource Conservation Recovery Program (S)
n-Nitrosodiphenylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosodiphenylamine	Resource Conservation Recovery Program (S)
n-Nitrosomethylethylamine	Resource Conservation Recovery Program (NPW)
n-Nitrosomethylethylamine	Resource Conservation Recovery Program (S)
n-Nitrosomorpholine	Resource Conservation Recovery Program (NPW)
n-Nitrosomorpholine	Resource Conservation Recovery Program (S)
n-Nitrosopiperidine	Resource Conservation Recovery Program (NPW)
n-Nitrosopiperidine	Resource Conservation Recovery Program (S)
n-Nitrosopyrrolidine	Resource Conservation Recovery Program (NPW)
n-Nitrosopyrrolidine	Resource Conservation Recovery Program (S)
o,o,o-Triethyl phosphorothioate	Resource Conservation Recovery Program (NPW)
o,o,o-Triethyl phosphorothioate	Resource Conservation Recovery Program (S)
o-Toluidine	Resource Conservation Recovery Program (NPW)
o-Toluidine	Resource Conservation Recovery Program (S)
Parathion	Resource Conservation Recovery Program (NPW)

Parathion	Resource Conservation Recovery Program (S)
Pentachlorobenzene	Resource Conservation Recovery Program (NPW)
Pentachlorobenzene	Resource Conservation Recovery Program (S)
Pentachloronitrobenzene	Resource Conservation Recovery Program (NPW)
Pentachloronitrobenzene	Resource Conservation Recovery Program (S)
Pentachlorophenol	Resource Conservation Recovery Program (NPW)
Pentachlorophenol	Resource Conservation Recovery Program (S)
Phenacetin	Resource Conservation Recovery Program (NPW)
Phenacetin	Resource Conservation Recovery Program (S)
Phenanthrene	Resource Conservation Recovery Program (NPW)
Phenanthrene	Resource Conservation Recovery Program (S)
Phenol	Resource Conservation Recovery Program (NPW)
Phenol	Resource Conservation Recovery Program (S)
Phorate	Resource Conservation Recovery Program (NPW)
Phorate	Resource Conservation Recovery Program (S)
p-Phenylenediamine	Resource Conservation Recovery Program (NPW)
p-Phenylenediamine	Resource Conservation Recovery Program (S)
Pronamide (Kerb)	Resource Conservation Recovery Program (NPW)
Pronamide (Kerb)	Resource Conservation Recovery Program (S)
Pyrene	Resource Conservation Recovery Program (NPW)
Pyrene	Resource Conservation Recovery Program (S)
Pyridine	Resource Conservation Recovery Program (NPW)
Pyridine	Resource Conservation Recovery Program (S)
Safrole	Resource Conservation Recovery Program (NPW)
Safrole	Resource Conservation Recovery Program (S)
Sulfotepp	Resource Conservation Recovery Program (NPW)
Sulfotepp	Resource Conservation Recovery Program (S)
EPA 8330	
1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (NPW)
1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (S)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (NPW)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (S)
2,4,6-Trinitrotoluene (2,4,6-TNT)	Resource Conservation Recovery Program (NPW)
2,4,6-Trinitrotoluene (2,4,6-TNT)	Resource Conservation Recovery Program (S)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (NPW)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (S)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (NPW)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (S)
2-Amino-4,6-dinitrotoluene (2-am-dnt)	Resource Conservation Recovery Program (NPW)
2-Amino-4,6-dinitrotoluene (2-am-dnt)	Resource Conservation Recovery Program (S)
2-Nitrotoluene	Resource Conservation Recovery Program (NPW)
2-Nitrotoluene	Resource Conservation Recovery Program (S)
3-Nitrotoluene	Resource Conservation Recovery Program (NPW)
3-Nitrotoluene	Resource Conservation Recovery Program (S)
4-Amino-2,6-dinitrotoluene (4-am-dnt)	Resource Conservation Recovery Program (NPW)
4-Amino-2,6-dinitrotoluene (4-am-dnt)	Resource Conservation Recovery Program (S)
4-Nitrotoluene	Resource Conservation Recovery Program (NPW)
4-Nitrotoluene	Resource Conservation Recovery Program (S)
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	Resource Conservation Recovery Program (NPW)
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	Resource Conservation Recovery Program (S)
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	Resource Conservation Recovery Program (NPW)
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	Resource Conservation Recovery Program (S)
Nitrobenzene	Resource Conservation Recovery Program (NPW)
Nitrobenzene	Resource Conservation Recovery Program (S)
Nitroglycerin	Resource Conservation Recovery Program (NPW)
Nitroglycerin	Resource Conservation Recovery Program (S)
Pentaerythritoltetranitrate	Resource Conservation Recovery Program (NPW)
Pentaerythritoltetranitrate	Resource Conservation Recovery Program (S)
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	Resource Conservation Recovery Program (NPW)
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	Resource Conservation Recovery Program (S)
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	Resource Conservation Recovery Program (NPW)
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	Resource Conservation Recovery Program (S)
EPA 8330A	
1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (NPW)

1,3,5-Trinitrobenzene (1,3,5-TNB)	Resource Conservation Recovery Program (S)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (NPW)
1,3-Dinitrobenzene (1,3-DNB)	Resource Conservation Recovery Program (S)
2,4,6-Trinitrotoluene (2,4,6-TNT)	Resource Conservation Recovery Program (NPW)
2,4,6-Trinitrotoluene (2,4,6-TNT)	Resource Conservation Recovery Program (S)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (NPW)
2,4-Dinitrotoluene (2,4-DNT)	Resource Conservation Recovery Program (S)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (NPW)
2,6-Dinitrotoluene (2,6-DNT)	Resource Conservation Recovery Program (S)
2-Amino-4,6-dinitrotoluene (2-am-dnt)	Resource Conservation Recovery Program (NPW)
2-Amino-4,6-dinitrotoluene (2-am-dnt)	Resource Conservation Recovery Program (S)
2-Nitrotoluene	Resource Conservation Recovery Program (NPW)
2-Nitrotoluene	Resource Conservation Recovery Program (S)
3-Nitrotoluene	Resource Conservation Recovery Program (NPW)
3-Nitrotoluene	Resource Conservation Recovery Program (S)
4-Amino-2,6-dinitrotoluene (4-am-dnt)	Resource Conservation Recovery Program (NPW)
4-Amino-2,6-dinitrotoluene (4-am-dnt)	Resource Conservation Recovery Program (S)
4-Nitrotoluene	Resource Conservation Recovery Program (NPW)
4-Nitrotoluene	Resource Conservation Recovery Program (S)
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	Resource Conservation Recovery Program (NPW)
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	Resource Conservation Recovery Program (S)
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	Resource Conservation Recovery Program (NPW)
Methyl-2,4,6-trinitrophenylnitramine (tetryl)	Resource Conservation Recovery Program (S)
Nitrobenzene	Resource Conservation Recovery Program (NPW)
Nitrobenzene	Resource Conservation Recovery Program (S)
Nitroglycerin	Resource Conservation Recovery Program (NPW)
Nitroglycerin	Resource Conservation Recovery Program (S)
Pentaerythritoltetranitrate	Resource Conservation Recovery Program (NPW)
Pentaerythritoltetranitrate	Resource Conservation Recovery Program (S)
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	Resource Conservation Recovery Program (NPW)
RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	Resource Conservation Recovery Program (S)
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	Resource Conservation Recovery Program (NPW)
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	Resource Conservation Recovery Program (S)
EPA 9012A	
Total Cyanide	Resource Conservation Recovery Program (NPW)
Total Cyanide	Resource Conservation Recovery Program (S)
EPA 9040C	
pH	Resource Conservation Recovery Program (S)
EPA 9045D	
pH	Resource Conservation Recovery Program (S)
EPA 9056 0	
Bromide	Resource Conservation Recovery Program (NPW)
Bromide	Resource Conservation Recovery Program (S)
Chloride	Resource Conservation Recovery Program (NPW)
Chloride	Resource Conservation Recovery Program (S)
Nitrate as N	Resource Conservation Recovery Program (NPW)
Nitrate as N	Resource Conservation Recovery Program (S)
Nitrite as N	Resource Conservation Recovery Program (NPW)
Nitrite as N	Resource Conservation Recovery Program (S)
Orthophosphate as P	Resource Conservation Recovery Program (NPW)
Orthophosphate as P	Resource Conservation Recovery Program (S)
Sulfate	Resource Conservation Recovery Program (NPW)
Sulfate	Resource Conservation Recovery Program (S)
EPA 9060A	
Total Organic Carbon	Resource Conservation Recovery Program (S)
EPA 9071B	
Oil & Grease	Resource Conservation Recovery Program (S)
MA EPH	
2-Methylnaphthalene	Leaking Underground Storage Tank Program (NPW)
2-Methylnaphthalene	Leaking Underground Storage Tank Program (S)
Acenaphthene	Leaking Underground Storage Tank Program (NPW)
Acenaphthene	Leaking Underground Storage Tank Program (S)
Acenaphthylene	Leaking Underground Storage Tank Program (NPW)

Acenaphthylene	Leaking Underground Storage Tank Program (S)
Anthracene	Leaking Underground Storage Tank Program (NPW)
Anthracene	Leaking Underground Storage Tank Program (S)
Benzo[a]anthracene	Leaking Underground Storage Tank Program (NPW)
Benzo[a]anthracene	Leaking Underground Storage Tank Program (S)
Benzo[a]pyrene	Leaking Underground Storage Tank Program (NPW)
Benzo[a]pyrene	Leaking Underground Storage Tank Program (S)
Benzo[b]fluoranthene	Leaking Underground Storage Tank Program (NPW)
Benzo[b]fluoranthene	Leaking Underground Storage Tank Program (S)
Benzo[g,h,i]perylene	Leaking Underground Storage Tank Program (NPW)
Benzo[g,h,i]perylene	Leaking Underground Storage Tank Program (S)
Benzo[k]fluoranthene	Leaking Underground Storage Tank Program (NPW)
Benzo[k]fluoranthene	Leaking Underground Storage Tank Program (S)
Chrysene	Leaking Underground Storage Tank Program (NPW)
Chrysene	Leaking Underground Storage Tank Program (S)
Dibenz[a,h]anthracene	Leaking Underground Storage Tank Program (NPW)
Dibenz[a,h]anthracene	Leaking Underground Storage Tank Program (S)
EPH Aliphatic C19-C36	Leaking Underground Storage Tank Program (NPW)
EPH Aliphatic C19-C36	Leaking Underground Storage Tank Program (S)
EPH Aliphatic C9-C18	Leaking Underground Storage Tank Program (NPW)
EPH Aliphatic C9-C18	Leaking Underground Storage Tank Program (S)
EPH Aromatic C11-C22	Leaking Underground Storage Tank Program (NPW)
EPH Aromatic C11-C22	Leaking Underground Storage Tank Program (S)
Fluoranthene	Leaking Underground Storage Tank Program (NPW)
Fluoranthene	Leaking Underground Storage Tank Program (S)
Fluorene	Leaking Underground Storage Tank Program (NPW)
Fluorene	Leaking Underground Storage Tank Program (S)
Indeno[1,2,3-cd]pyrene	Leaking Underground Storage Tank Program (NPW)
Indeno[1,2,3-cd]pyrene	Leaking Underground Storage Tank Program (S)
Naphthalene	Leaking Underground Storage Tank Program (NPW)
Naphthalene	Leaking Underground Storage Tank Program (S)
Phenanthrene	Leaking Underground Storage Tank Program (NPW)
Phenanthrene	Leaking Underground Storage Tank Program (S)
Pyrene	Leaking Underground Storage Tank Program (NPW)
Pyrene	Leaking Underground Storage Tank Program (S)
MA VPH	
Benzene	Leaking Underground Storage Tank Program (NPW)
Benzene	Leaking Underground Storage Tank Program (S)
Ethylbenzene	Leaking Underground Storage Tank Program (NPW)
Ethylbenzene	Leaking Underground Storage Tank Program (S)
Methyl tert-butyl ether (MTBE)	Leaking Underground Storage Tank Program (NPW)
Methyl tert-butyl ether (MTBE)	Leaking Underground Storage Tank Program (S)
Naphthalene	Leaking Underground Storage Tank Program (NPW)
Naphthalene	Leaking Underground Storage Tank Program (S)
Toluene	Leaking Underground Storage Tank Program (NPW)
Toluene	Leaking Underground Storage Tank Program (S)
VPH Aliphatic C5-C8	Leaking Underground Storage Tank Program (NPW)
VPH Aliphatic C5-C8	Leaking Underground Storage Tank Program (S)
VPH Aliphatic C9-C12	Leaking Underground Storage Tank Program (NPW)
VPH Aliphatic C9-C12	Leaking Underground Storage Tank Program (S)
VPH Aromatic C9-C10	Leaking Underground Storage Tank Program (NPW)
VPH Aromatic C9-C10	Leaking Underground Storage Tank Program (S)
Xylene (total)	Leaking Underground Storage Tank Program (NPW)
Xylene (total)	Leaking Underground Storage Tank Program (S)
ME HETL 4.1.25	
Diesel range organics (DRO)	Leaking Underground Storage Tank Program (NPW)
Diesel range organics (DRO)	Leaking Underground Storage Tank Program (S)
ME HETL 4.2.17	
Gasoline range organics (GRO)	Leaking Underground Storage Tank Program (NPW)
Gasoline range organics (GRO)	Leaking Underground Storage Tank Program (S)
SimPlate®	
Heterotrophic plate count	Safe Drinking Water Program (DW)
SM 2120 B 21st ED	

Color	Clean Water Program (NPW)
SM 2130 B 21st ED	
Turbidity	Clean Water Program (NPW)
SM 2310 B 21st ED	
Acidity, as CaCO3	Clean Water Program (NPW)
SM 2320 B 20th ED	
Alkalinity as CaCO3	Clean Water Program (NPW)
SM 2320 B 21st ED	
Alkalinity as CaCO3	Clean Water Program (NPW)
SM 2340 B 21st ED	
Hardness	Clean Water Program (NPW)
SM 2540 B 21st ED	
Residue-total (TS)	Clean Water Program (NPW)
SM 2540 C 21st ED	
Residue-filterable (TDS)	Clean Water Program (NPW)
SM 2540 D 21st ED	
Residue-nonfilterable (TSS)	Clean Water Program (NPW)
SM 2540 F 21st ED	
Residue-settleable	Clean Water Program (NPW)
SM 3500-Cr D 19th ED	
Chromium VI	Clean Water Program (NPW)
SM 3500-Fe D 19th ED	
Iron	Clean Water Program (NPW)
SM 4500-Cl G 20th ED	
Chlorine	Clean Water Program (NPW)
SM 4500-Cl^- E 21st ED	
Chloride	Clean Water Program (NPW)
SM 4500-CN G 20th ED	
Amenable cyanide	Clean Water Program (NPW)
SM 4500-F^- B 21st ED	
Fluoride	Safe Drinking Water Program (DW)
SM 4500-F^- C 21st ED	
Fluoride	Clean Water Program (NPW)
SM 4500-H+ B 21st ED	
pH	Clean Water Program (NPW)
SM 4500-NH3 H 21st ED	
Ammonia as N	Clean Water Program (NPW)
SM 4500-P E 20th ED	
Orthophosphate as P	Clean Water Program (NPW)
SM 4500-$S2^-$ F 21st ED	
Sulfide	Clean Water Program (NPW)
SM 4500-$SO3^-$ B 21st ED	
Sulfite	Clean Water Program (NPW)
SM 5210 B 21st ED	
Biochemical oxygen demand	Clean Water Program (NPW)
Carbonaceous BOD, CBOD	Clean Water Program (NPW)
SM 5310 B 21st ED	
Total Organic Carbon	Clean Water Program (NPW)
SM 5540 C 20th ED	
Surfactants - MBAS	Clean Water Program (NPW)
SM 9222 D (m-FC) 21st ED	
Fecal coliforms	Clean Water Program (NPW)
Fecal coliforms	Safe Drinking Water Program (DW)
SM 9223 B (Colilert® Quanti-Tray®) 21st ED	
Total coliforms	Safe Drinking Water Program (DW)
SM 9223 B (Colilert®) 21st ED	
Escherichia coli	Safe Drinking Water Program (DW)
SM 9223 B (Colilert®-18 Quanti-Tray®) 21st ED	
Escherichia coli	Clean Water Program (NPW)
SM 9223 B (Colisure® Quanti-Tray®) 21st ED	

APPENDIX D

HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

The following risk assessment work plan was prepared to support the Site 12 Remedial Investigation at Naval Air Station (NAS) Brunswick, Brunswick, Maine. This work plan provides the human health risk assessment (HHRA) protocol that will be used to evaluate chemical concentrations in soil, groundwater, and sediment at Site 12. The risk assessments will be performed to evaluate whether hazardous substances at the site pose potential human health to exposed receptors under current or hypothetical future land use. The risk assessment address a variety of chemicals in the soil, groundwater, and sediment matrices, exposure pathways, and receptors as a basis for characterizing the types and range of potential risks associated with site-related contamination.

1.0 HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

The overall objective of the HHRA is to determine the potential for health risks in the absence of remedial action at the site and, if action is required, to focus the risk evaluation of remedial alternatives (RERA).

The following current risk assessment guidance documents were primarily used to develop the HHRA methodology:

- Department of Defense (DoD) Vapor Intrusion Handbook (DoD, 2009).
- Conducting Human Health Risk Assessments Under the Environmental Restoration Program, Chief of Naval Operations (N45) 5090 Ser N453E/1U595168, Feb 12, 2001 (Navy, 2001)
- Navy Policy on the Use of Background Chemical Levels, Chief of Naval Operations 5090 Ser N45C/N4U732212, Jan 30, 2004. (Navy, 2004)
- U.S. Navy Human Health Risk Assessment Guidance. (Navy, 2008). http://www-nmcphc.med.navy.mil/downloads/ep/Chapters%201-12.pdf
- Risk Assessment Guidance for Superfund: Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989).
- Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. Washington, D.C. Office of Solid Waste and Emergency Response (OSWER) Directive 9285.6-03 (USEPA, 1991).

- Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C. (USEPA, 1993a).

- Guidance for Human Health Risk Assessments for Hazardous Substance Sites in Maine. State of Maine Department of Environmental Protection and Center for Disease Control (MEDEP, 2009a).

- Remediation Guidelines for Petroleum Contaminated Sites in Maine. Maine Department of Environmental Protection Bureau of Remediation and Waste Management (MEDEP, 2009b).

- Soil Screening Guidance: Technical Background Document. Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/R-95/128 (USEPA, 1996).

- Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments) (USEPA, 2001a).

- Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, Washington, D.C. OSWER 9285.6-10 (USEPA, 2002a).

- OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance). EPA 530-D-02-004 (USEPA, 2002b).

- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Final. Office of Superfund Remediation and Technology Innovation, Washington, D.C. 20460 EPA/540/R/99/005, OSWER 9285.7-02EP; PB99-963312 (USEPA, 2004).

- Guidelines for Carcinogen Risk Assessment. Risk Assessment Forum, Washington, DC. EPA/630/P-03/001B. (USEPA, March 2005).

- Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum, Washington, DC. EPA/630/R-03/003F (USEPA, March 2005).

- Child-Specific Exposure Factors Handbook. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/R-06/096F (USEPA, 2008).
- Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment) (USEPA, 2009a).
- Exposure Factors Handbook. Office of Health and Environmental Assessment, Washington, D.C. EPA/600/R-090/052F (USEPA, 2011).
- Vapor Intrusion Evaluation Guidance. http://www.maine.gov/dep/rwm/publications/guidance (MEDEP, January 2010).

The HHRA is comprises following components:

- Data Evaluation Protocol
- Exposure Assessment
- Toxicity assessment
- Risk Characterization
- Uncertainty Analysis
- Derivation of Cleanup Goals

The HHRA will be structured and reported according to the guidelines of the Risk Assessment for Superfund (RAGS), Human Health Evaluation Manual, Part D: Standardized Planning, Reporting, and Review of Superfund Risk Assessments (RAGS Part D).

1.1 Data Evaluation

Data evaluation, the first component of a baseline HHRA, is a two-step, media-specific task involving the compilation and evaluation of analytical data. The first step involves the compilation of the analytical database and an evaluation of data usability for purposes of the HHRA.

The second step of the data evaluation is the selection of a medium-specific list of chemical of potential concern (COPCs), which will be used to quantitatively or qualitatively determine potential human health risks for site media. COPCs are selected based on a toxicity screen (a comparison of site contaminant concentrations to conservative toxicity screening values) and a background screen (a comparison of site

concentrations to background concentrations such as those in the Background Study Report for Naval Air Station Brunswick, [Tetra Tech, 2012]). Risks will be calculated for non-site related chemicals (i.e., chemicals detected at concentrations less than background concentrations); however, non-site related risk will be evaluated separately from site related risks for informational purposes.

1.1.1 Toxicity Screen

COPCs for the site will be selected via the direct contact pathway (i.e., inhalation, dermal contact, and ingestion), groundwater protection soil screening levels (SSLs), and the indoor air (vapor intrusion) pathway.

Direct Contact Pathway Evaluation

USEPA Regional Screening Levels (RSLs) for residential soil and tapwater will be used to select COPCs for the direct contact exposure pathway with soil and groundwater, respectively, with the exception of the extractable petroleum hydrocarbon (EPH) and volatile petroleum hydrocarbon (VPH) fractions EPH and VPH results will be compared to criteria specified in "Remediation Guidelines For Petroleum Contaminated Sites in Maine" as specified in Worksheet #15 of this SAP. Initially sediment data will be screened for COPC selection against residential soil RSLs; however, site-specific sediment screening values may be developed. The USEPA RSL concentrations are based on exposure pathways for which generally accepted methods, models, and assumptions have been developed (i.e., ingestion, dermal contact, and inhalation) for specific land-use conditions. The risk-based screening concentrations will correspond to a systemic hazard quotient (HQ) of 0.1 for noncarcinogens or an incremental lifetime cancer risk of 1 $x10^{-6}$ for carcinogens. The USEPA RSLs for noncarcinogens are based on a HQ of 1.0, whereas the screening concentrations will be based on an HQ of 0.1. The screening concentrations are based on an HQ of 0.1 to account for the potential cumulative effects of several chemicals affecting the same target organ or producing the same adverse non-carcinogenic effect.

Migration to Groundwater Pathway Evaluation

USEPA groundwater protection risk-based SSLs will be compared to maximum detected site concentrations for the selection of COPCs. The risk-based SSLs for groundwater protection are based on a dilution attenuation factor (DAF) of 1, which is the lowest DAF value possible and assumes that no reduction in concentration occurs as the contaminant moves from the source to groundwater, or in other words, that the concentrations at the source and in groundwater are the same (i.e., a receptor is exposed to the leachate concentration). If COPCs are selected for the migration to groundwater pathway, a qualitative evaluation will be used to further evaluate the COPCs. The qualitative evaluation will consider

magnitudes of COPC concentrations, frequency of criteria exceedances, and whether COPC concentrations exceed groundwater protection SSLs based on a DAF of 20, which is generally assumed to be more accurate at most sites, or Maximum Contaminant Level (MCL-based) SSLs. Additionally, site-specific groundwater data will be evaluated to determine whether or not contaminants exceeding SSLs, if any, are actually present in groundwater. If a contaminant exceeds an SSL but is not present in groundwater professional judgment based on additional site-specific considerations (e.g. soil type) will be used to determine whether such a contaminant is actually leaching from soil to groundwater.

Vapor Intrusion Pathway Evaluation

Potential vapor intrusion (VI) sources in soil and groundwater will be investigated in accordance with current USEPA Vapor Intrusion Guidance (USEPA, 2002b), Department of Defense Vapor Intrusion Handbook (DoD, 2009), and Maine Department of Environmental Protection (MEDEP) Vapor Intrusion Guidance (MEDEP, 2010).

The primary VI screening will be a qualitative evaluation to determine whether potential VI sources exist. Chemicals of sufficient volatility and toxicity to pose a VI concern will be screened for positive detections. If positive detections of a contaminant of sufficient volatility and toxicity to pose a VI concern exist, than the magnitude and frequency of those detections will be evaluated to qualitatively determine if a VI source may exist. Finally, if a qualitative evaluation of chemical data provides evidence that a VI source exists, than the concentrations of contaminants contributing to the VI source will be plotted on a map of the site (e.g. tag map) to further evaluate whether or not a VI source may exist. The RI will provide recommendations for whether or not further investigation of potential VI soil sources is warranted.

1.1.2. Background Screen

Background concentrations are concentrations that would exist in the absence of influence from site operations. A background screening will be conducted for all chemicals included in the COPC screening process (i.e., chemicals yielding detections), as discussed herein. Site data will be compared to background using lines-of-evidence such as site-specific facility background data or the pending MEDEP background PAH values which are expected to be added to Maine's Remedial Action Guidelines (RAGs) Appendix 1 and 2 tables.

To compare site ISM samples to site-specific facility background data the 95 percent upper confidence limits (UCLs) will be calculated on site ISM data for those areas of the site being compared to background that have at least 3 ISM samples using the 95% UCL calculator for ISM data provided in Section 4 of the 2012 ITRC Incremental Sampling Methodology guidance. If any of the ISM 95% UCL results for a given COPC are greater than the corresponding 95% UCL of the site-specific facility background then that

COPC will be considered greater than background. If a 95% UCL for a COPC is less than or equal to the 95% UCL of the site-specific facility background for that same chemical then that COPC will be considered consistent with background.

An additional comparison will then be conducted. For any COPCs identified based on the site-specific facility background comparison, the site 95% UCLs will subsequently be compared to the corresponding MEDEP 95% UCL background value. Results of this secondary comparison will be discussed in the Uncertainty Analysis and results will be considered during future risk management decision discussions with regulators.

For comparison to the MEDEP background PAH values, if any of the ISM samples exceed the background value the chemical will be considered greater than background; if all of the ISM samples are less than or equal to the MEDEP background value the site concentration will be considered consistent with background.

Total risks (site plus background) will be presented separately for informational purposes. Background data will be used to identify site-related chemicals and site-related risks.

1.1.3 Selection of COCPs

The COPC selection process is as follows:

Step 1: The maximum detected concentration of an analyte in an ISM sample will be compared with the toxicity screening values previously defined. It is important to note that an ISM sample is an average concentration across a given area and is not representative of the maximum concentration of any given grab sample used to create the ISM sample. If the maximum detected ISM sample concentration is less than the screening value, the parameter is not retained for quantitative risk assessment. Additionally, essential nutrients (i.e., calcium, magnesium, potassium, and sodium) are not selected as COPCs.

Step 2: A constituent detected at concentrations less than background will not be identified as a COPC and will not be included in risk estimates calculated in the primary risk summary tables.

Because of the lack of toxicity criteria, risk-based COPC screening levels are not available for some chemicals (e.g., acenaphthylene, benzo(g,h,i)perylene, and phenanthrene). For these constituents, surrogate chemicals (which have toxicity criteria) will be used for screening purposes. For example, acenaphthene will be used as a surrogate for acenaphthylene, and pyrene will be used as a surrogate for benzo(g,h,i)perylene and phenanthrene.

The results of the COPC selection will be summarized in tables prepared according to RAGS Part D guidance (RAGS Part D Table 2). The rationale for the inclusion or exclusion of chemicals as COPCs will be clearly presented.

1.2 Exposure Assessment Protocol

The exposure assessment component of a baseline HHRA defines and provides a means to evaluate, quantitatively or qualitatively, the type and magnitude of human exposure to chemicals present at or migrating from a site. A foundation of the exposure assessment is the conceptual site model (CSM), which identifies site characteristics including potential contaminant sources, contaminant release mechanisms, transport routes, receptors, and other appropriate information. The CSM must consider both current and future land use scenarios and integrates information regarding the physical characteristics of the site, exposed populations, sources of contamination, and contaminant mobility (fate and transport) to identify potential exposure routes and receptors evaluated in the risk assessment. A well-defined CSM allows for a better understanding of the risks at a site and aids risk managers in the identification of the potential need for remediation. The following sections summarize the Site 12 CSM:

1.2.1 Conceptual Site Model

Sources of Contamination

Site 12 is an Explosive Ordnance Disposal (EOD) Area and potential sources of soil, groundwater, and sediment contamination include munitions constituents (MC) from discarded munitions. Environmental media will also be sampled for a full suite of CERCLA contaminants (e.g. Target Compound List Pesticides) to determine if any other types of hazardous wastes are present.

Potential Contaminant Migration Mechanisms

Potential contaminant migration pathways include dissolution and migration from soil to groundwater, erosion and overland runoff, and VI.

Dissolution of contaminants associated with Site 12 in infiltrating precipitation with subsequent lateral migration will be investigated to determine if that is a significant migration pathway. Potential migration via dissolution from precipitation and subsequent lateral migration will be evaluated using SSLs as described in Section 1.1.1

Erosion and overland runoff are potential migration mechanisms if contaminants are exposed. Fine-grained soils such as clays tend to accumulate a greater mass of chemical contaminants than large-grained soils, such as sand, and tend to be transported via overland runoff to lower elevations during rain events. If contaminated matrices (soils) are uncovered, contaminant transport of dissolved and suspended particulates in overland runoff would occur at the rate of overland flow. Overland flow particles could eventually settle into stream or pond sediments if this potential transport mechanism occurred.

Potential VI sources in soil will be investigated as described in Section 1.1.1.

Land Uses and Potential Exposure

Site 12 has been used for the disposal of ordnance, pyrotechnics, privately manufactured explosive devices, and war souvenirs. On June 1, 2004, EOD activities at NAS Brunswick were officially terminated. Potential future land use is anticipated as the Brunswick Naval Air Station (BNAS) Conservation District (Natural Area).

1.2.2 Human Health Receptors

Following is a discussion of the potential human health receptors. Currently potential human receptors include occupational workers, construction workers, and trespassers. Future potential human receptors include residents, occupational workers, construction workers, and recreational users. Future residential use of the site is not currently planned; however, hypothetical future residential use is evaluated as a risk scenario that could occur if the sites were developed for residential use.

Current and Future Construction Workers – an onsite receptor under current or future land use. Construction workers could be exposed to contamination surface and subsurface soil via incidental ingestion, dermal contact, and air (inhalation), sediment via incidental ingestion and dermal contact, and groundwater via incidental ingestion, dermal contact, and air (inhalation).

Current Trespassers (Adolescents and Adults) – an onsite receptor under current land use who may spend time outdoors recreating (e.g., walking, playing sports). A trespasser may be exposed to surface soil via incidental ingestion, dermal contact, and inhalation or sediment via incidental ingestion and dermal contact. Trespasser exposure to subsurface soil would only occur if subsurface soils were excavated and deposited on existing surface soils.

Future Recreational Users (Children and Adults) – an onsite receptor under future land use who may spend time outdoors recreating (e.g., walking, playing sports). A recreational user may be exposed to surface soil via incidental ingestion, dermal contact, and inhalation or sediment via incidental ingestion

and dermal contact. Receptor exposure to subsurface soil would only occur if subsurface soils were excavated and deposited on existing surface soils.

Hypothetical Future Residents (Children and Adults) – Future child and adult residents, assuming the land use is changed to residential. The hypothetical future resident is expected to be exposed to surface soil by incidental ingestion, dermal contact, and inhalation assuming that soil is uncovered (no grass or asphalt) and indoor air. A future hypothetical resident may also be exposed to groundwater via ingestion, dermal contact, and inhalation if the groundwater was used as a drinking water source. The hypothetical future resident could be exposed to sediment via incidental ingestion and dermal contact if wading in surface water bodies at Site 12. Receptor exposure to subsurface soil would only occur if subsurface soils were excavated and deposited on existing surface soils.

1.2.3 Calculation of Exposure Point Concentrations

The exposure point concentration (EPC), which is calculated for COPCs only, is an estimate of the chemical concentrations within an exposure unit likely to be contacted over time by a receptor and is used to estimate exposure intakes. The following paragraphs discuss the relationship between the terms “site” and EU in reference to calculating the EPC and the guidelines for calculating the EPC.

An “exposure unit” (EU) is the area over which receptor activity is expected to occur. The two most important considerations in defining an EU are the anticipated receptor activity and the spatial distribution of contaminant concentrations. Exposure units will be determined following data collection by comparing chemical concentration distributions in DUs to each other to determine whether or not DUs with similar chemical distributions can be combined. If chemical data from any give DU cannot be combined with another DU to form an EU than that DU will be evaluated as an individual EU.

To determine if COPC between DUs are similar side by side box plots will be utilized. Box plots show the central tendency, degree of symmetry, range of variation, and potential outliers of a dataset. The dataset is shown as a rectangular box that represents the middle 50 percent of the data. The upper value of the box represents the 75th percentile and the lower value of the box represents the 25th percentile. The median is represented by the middle line in the box. Box plots for the same analyte in the two datasets will be plotted on the same graph. Whiskers will be drawn from the box extending outward to 1.5 times the interquartile range (difference between 75th and 25th percentiles). Concentrations that are less than the lower whisker and greater than the upper whisker are potential outliers and will be plotted as circles. If the median concentration of a given chemical in one DU falls below the 75th percent and above the 25th percentile of that same chemical in another DU the chemical concentrations in the two DUs will be considered similar. Otherwise the chemical concentrations will not be considered similar.

The available data sets for the site will be evaluated to assure that the data are adequate and acceptable for risk assessment (i.e., there are no data gaps) prior to the calculation of EPCs. If the data sets are found to be inadequate, the project stakeholders (Navy, USEPA, MEDEP) will discuss and agree how to proceed. Sample and duplicate analytical results will be averaged.

EPCs concentrations will be determined as follows. Surface and subsurface soil and sediment EPCs will be calculated for each EU by averaging available ISM COPC concentration results. If only one ISM sample is available for a given EU then the concentrations of COPCs in that sample will be used to represent the EPC for that EU. . The maximum detected groundwater concentrations will be selected as groundwater EPCs. The mean lead concentration for each data set will represent the EPC for lead.

1.2.4 Chemical and Intake Estimation

Estimates of exposure are based on the contaminant concentrations at the exposure points and on scenario-specific assumptions and intake parameters. The most recent USEPA and MEDEP guidance (e.g., the Exposure Factors Handbook [USEPA, 2011]and Maine's Guidance for Human Health Risk Assessments for Hazardous Substance Sites in Maine [MEDEP, 2009]) will be used to estimate intakes. In general, standard default parameters, which combine mid-range and upper-end exposure factors, will be used to assess exposures; however, site specific parameters will be utilized when applicable. The equations and exposure parameters obtained from USEPA and MEDEP guidance documents that will be used to quantify intakes and intake parameters are summarized in the RAGS Part D Table 4s, provided in Attachment B.

Traditionally, exposures evaluated in the HHRA have been based on the concept of reasonable maximum exposure (RME), defined as "the maximum exposure that is reasonably expected to occur at a site" (USEPA, 1989a). However, more recent risk assessment guidance (USEPA, 1992), recommends addressing an average case, or Central Tendency Exposure (CTE). The available guidance concerning the evaluation of CTE (USEPA, 1993a) is limited; however, the CTE will be evaluated for each receptor to provide a greater perspective about site risks for risk managers than just the RME scenario alone.

USEPA's Supplemental Guidance for Assessing Susceptibility from Early Life Exposure to Carcinogens (2005b) recommends adjusting the toxicity of carcinogenic chemicals that act via the mutagenic mode of action when evaluating early-life exposures to contaminants. The guidance recommends using age-dependent adjustment factors (ADAFs) in concert with age-specific exposure estimates when assessing cancer risks. Absent chemical-specific data, the supplemental guidance recommends the following

default adjustments, which reflect that cancer risks are generally higher from early-life exposures than from similar exposures later in life:

- For exposures before two years of age (i.e., spanning a two-year interval from the first day of birth until a child's second birthday), a 10-fold adjustment.

- For exposures between two and less than 16 years of age (i.e., spanning a 14-year time interval from a child's second birthday until a child's sixteenth birthday), a three-fold adjustment.

- For exposures after reaching 16 years of age, no adjustment.

These adjustments are applied using the same method as that used by USEPA to develop the RSLs. Children will be evaluated in two age groups, ages 0–2 and 2–6 years old. Adults will be evaluated as two age groups (6-16 and 16–30 years old). Using this approach, the intakes for child and adult recreational users and residents were calculated for the RME scenario as follows:

$$\text{Intake}_{\text{Child}} = \text{Intake}_{(\text{ages 0 to 2 years})} \times 10 + \text{Intake}_{(\text{ages 2 to 6 years})} \times 3$$
$$\text{Intake}_{\text{Adult}} = \text{Intake}_{(\text{age 6 to 16 years})} \times 3 + \text{Intake}_{(\text{ages 16 to 30 years})} \times 1$$

This approach will be used only for the chemicals planned for analysis that are identified as mutagenic in the USEPA RSL table (e.g., benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene). Sample calculations showing how this approach was applied will be included in an appendix to the HHRA. In addition, risks to lifelong recreational users and lifelong resident receptors will be evaluated. Risks to these receptors are sums of the cancer risks calculated for individual children and adult receptors. Therefore, lifelong cancer risks from chemicals that act via the mutagenic pathway are assessed through the lifelong recreational user and lifelong resident receptor scenarios.

Lead (if selected as a COPC) will be evaluated using the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in children Windows Version 1.1, Build 11 (USEPA, 2010b). Exposure of adults (workers and recreational users) to lead will be evaluated by the adult exposure model presented in the following USEPA document: Recommendations of the Technical Review Workgroup for Lead for an Approach to Assessing Risks Associated with Adult Exposures to Lead in Soils (USEPA, January 2003a). The following paragraphs provide a brief overview of these models.

The IEUBK model is recommended by USEPA for the evaluation of childhood lead exposures assuming a residential land use scenario. The IEUBK is designed to estimate blood-lead levels in children (under

7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood-lead levels. The results of the IEUBK modeling are given in terms of the probability that exposed children will exceed a 10 ug/dL blood-lead level. This probability is typically compared to the USEPA goal of limiting the childhood risk of exceeding a 10 ug/dL blood-lead concentration to 5 percent. The 400 mg/kg USEPA RSL for lead for residential land use is based on the IEUBK model.

The USEPA Technical Review Workgroup (TRW) Adult Lead Model (ALM) focuses on assessing risks associated with non-residential adult exposures to lead in soils. The model was originally published to provide guidance on the calculation of soil clean-up levels based on protecting adults (specifically, women of childbearing age) using a conservative approach that relates the lead level in the environment with the blood-lead level of a developing fetus. The output of the model is the risk (i.e., the probability) that elevated fetal blood-lead concentrations (i.e., concentrations greater than 10 ug/dL) will result due to exposures to women of childbearing age.

If the IEUBK model is run for lead, the input parameters other than the site arithmetic mean soil lead concentration will be USEPA default values. The IEUBK model output files, which include the default input parameters, will be included in an appendix to the HHRA. If the ALM is run for lead, the non-default input parameters to the ALM are the arithmetic mean soil lead concentration and receptor-specific ingestion rates and exposure frequencies, which are based on Central Tendency Exposure (CTE) exposure assumptions (included in the RAGS Part D Table 4s). The receptors evaluated by the ALM are non-residents. In this HHRA, the ALM would be used to evaluate lead exposures for construction workers, industrial workers, and adult recreational users. The receptor-specific input parameters will be in the model output files, which will be included in an appendix to the HHRA, and the receptor-specific input parameters will also be discussed in the text.

1.3 Toxicity Assessment

The objective of the toxicity assessment is to identify the potential adverse health effects in exposed populations. Quantitative estimates of the relationship between the magnitude and type of exposures and the severity or probability of human health effects are defined for the identified constituents of concern. Quantitative toxicity values determined during this component of the risk assessment are integrated with outputs of the exposure assessment to characterize the potential for the occurrence of adverse health effects for each receptor group.

The reference dose (RfD) is the toxicity value used to evaluate non-carcinogenic health effects for ingestion and dermal exposures. The reference concentration (RfC) is used to evaluate non-carcinogenic health effects for inhalation exposures. The RfD and RfC estimate the daily exposure level for the human population that is likely to be without appreciable risk during a portion or all of a lifetime. Those are based on a review of available animal and/or human toxicity data, with adjustments for various uncertainties associated with the data. Carcinogenic effects are quantified using the cancer slope factor (CSF) for ingestion and dermal exposures, and using inhalation unit risks (IURs) for inhalation exposure that are plausible upper-bound estimates of the probability of development of cancer per unit intake of chemical over a lifetime. The probability is based on available dose-response data from human and/or animal studies.

1.3.1 Toxicity Criteria for Oral and Inhalation Exposures

Oral RfDs and CSFs and inhalation RfCs and IURs to be used in the site-specific risk assessments will be obtained from the following primary USEPA literature sources (USEPA, 2003b):

- Tier 1 - Integrated Risk Information System (IRIS).

- Tier 2 - USEPA Provisional Peer Reviewed Toxicity Values (PPRTVs) – The Office of Research and Development/National Center for Environmental Assessment (NCEA) Superfund Health Risk Technical Support Center develops PPRTVs on a chemical specific basis when requested by USEPA's Superfund program.

- Tier 3 - Other Toxicity Values – These sources include but are not limited to California Environmental Protection Agency (Cal EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), and the Annual Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b).

Although RfDs and CSFs can be found in several toxicological sources, USEPA's IRIS online database is the preferred source of toxicity values.

1.3.2 Toxicity Criteria for Dermal Exposure

RfDs and CSFs found in literature are typically expressed as administered (not absorbed) doses. Therefore, these values are considered to be inappropriate for estimating the risks associated with the dermal route of exposure. Oral dose-response parameters based on administered doses must be adjusted to absorbed doses before the comparison to estimated dermal exposure intakes is made.

The adjustment to an absorbed dose will be made using chemical-specific gastrointestinal absorption efficiencies published in USEPA dermal guidance (USEPA, 2004) using the following equations:

$$RfD_{dermal} = (RfD_{oral})(ABS_{GI})$$

$$CSF_{dermal} = (CSF_{oral}) \ / \ (ABS_{GI})$$

where: ABS_{GI} = absorption efficiency in the gastrointestinal tract
RfD_{dermal}= reference dose for the dermal route of exposure
RfD_{oral} = reference dose for the oral route of exposure
CSF_{dermal}= cancer slope factor for the dermal route of exposure
CSF_{oral} = cancer slope factor for the oral route of exposure

As noted above, the preceding adjustment of the oral toxicity criteria is necessary so that the dermal route of exposure may be quantitatively evaluated in the baseline risk assessment. Explanations and the need for this procedure are presented in Appendix A of USEPA RAGS Part A (USEPA, 1989). The sources or rationale for ABS_{GI} values used in risk calculations will be documented in the HHRA if any COPCs lack published ABS_{GI} values in RAGS Part E.

1.4 Risk Characterization Protocol

Potential risks (non-carcinogenic and carcinogenic) for human receptors resulting from the potential exposures outlined in the exposure assessment are quantitatively determined during the risk characterization component of the HHRA. The quantitative estimates of risk are calculated in accordance with the risk assessment methods outlined in USEPA guidance (USEPA, 1989).

1.4.1 Quantitative Analysis of Chemicals

Quantitative estimates of risk for chemicals will be calculated according to risk assessment methods outlined in USEPA and MEDEP guidance (USEPA, 1989 and MEDEP, 2009). Lifetime cancer risks will be expressed in the form of dimensionless probabilities, referred to as incremental lifetime cancer risks (ILCRs), based on CSFs. Non-carcinogenic risk estimates will be presented in the form of hazard quotients (HQs) that are determined through a comparison of intakes with published RfDs.

ILCR estimates for ingestion and dermal exposures are generated for each COPC using estimated exposure intakes and published CSFs, as follows:

$$ILCR = (\text{Estimated Exposure Intake})(CSF)$$

Where:

ILCR = Incremental Lifetime Cancer Risk for a COPC (unitless)

Estimated Exposure Intake = oral or dermal chemical intake for a receptor [milligram per kilogram per day (mg/kg/day)]

CSF = oral or dermal cancer slope factor for a COPC $(mg/kg/day)^{-1}$

If the above equation results in an ILCR greater than 0.01, the following equation will be used:

$$ILCR = 1-[\exp(-\text{Estimated Exposure Intake})(CSF)]$$

ILCR estimates for inhalation exposures were generated for each COPC using estimated exposure concentrations and published IURs, as follows:

$$ILCR = [IUR][\text{Exposure Concentration}][1000 \text{ micrograms per milligram}(\mu g/mg)]$$

Where:

IUR = inhalation unit risk for a COPC $((\mu g/m^3)^{-1}$; where m^3 = meters cubed
Exposure Concentration = inhalation chemical intake for a receptor (mg/m^3)

An ILCR of 1×10^{-6} indicates that the exposed receptor has a one-in-one-million chance of developing cancer under the defined exposure scenario. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of one million persons.

As mentioned previously, non-carcinogenic risks will be assessed using the concept of HQs and hazard indices (His). The HQ for a COPC is the ratio of the estimated intake to the RfD, as follows for ingestion and dermal exposures:

$$HQ = (\text{Estimated Exposure Intake})/(RfD)$$

Where:

HQ = Hazard Quotient for a COPC (unitless)

Estimated Exposure Intake = oral or dermal chemical intake for a receptor (mg/kg/day)
RfD = inhalation reference dose for a COPC (mg/kg/day)

For inhalation exposures, HQ is calculated as follows:

$$HQ = (\text{Exposure Concentration})/(\text{RfC})$$

Where:

Exposure concentration = inhalation chemical intake for a receptor (mg/m^3)
RfC = inhalation reference concentration for a COPC (mg/m^3)

An HI will be generated by summing the individual HQs for all COPCs. The HI is not a mathematical prediction of the severity of toxic effects and is not a true "risk"; it is simply a numerical indicator of the possibility of the occurrence of non-carcinogenic (threshold) effects.

1.4.2 Interpretation of Risk Assessment Results

To interpret the quantitative risk estimates and to aid risk managers in determining the need for remediation, quantitative risk estimates will be compared to typical USEPA and MEDEP risk benchmarks. Calculated ILCRs will be interpreted using the USEPA target range (1×10^{-6} to 1×10^{-4}) and State of Maine's risk benchmark (1×10^{-5}), and HIs will be evaluated using a value of 1.0 for target organs and critical effects. Current USEPA policy regarding lead exposures is to limit the childhood risk of exceeding a 10 microgram per decilitler (µg/dL) blood-lead level to 5 percent.

USEPA has defined the range of 1×10^{-6} to 1×10^{-4} as the ILCR target range for hazardous waste facilities addressed under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA). Individual or cumulative ILCRs greater than 1×10^{-4} are generally considered to be "unacceptable" by the USEPA. Risk management decisions are necessary when the ILCR is within 1×10^{-4} to 1×10^{-6}. Remediation is typically not required by the USEPA when the cumulative ILCR does not exceed 1×10^{-6}. Similarly, cumulative ILCRs greater than 1×10^{-5} are generally considered to be "unacceptable" by the State of Maine.

An HI exceeding unity (1.0) for a target organ or critical effect indicates that there may be non-carcinogenic health risks associated with exposure. If an HI exceeds unity, target organ effects associated with exposure to COPCs are considered. Only those HQs for chemicals that affect the same target organ(s) or exhibit similar critical effect(s) are regarded as truly additive. Consequently, it may be

possible for a cumulative HI to exceed 1.0, but no adverse health effects are anticipated if the COPCs do not affect the same target organ or exhibit the same critical effect.

Lead is evaluated separately from other chemicals. The results of the IEUBK model and ALM model will be compared to the USEPA limit of 5 percent of children having a blood-lead concentration exceeding µg/dL. If a model output indicates that more than 5 percent of children are expected to have blood-lead concentrations exceeding 10 µg/dL, the risk is typically considered unacceptable.

1.5 Human Health Risk Uncertainty Analysis

The baseline risk assessment will include an uncertainty analysis that qualitatively addresses major sources of uncertainty in the data evaluation, exposure assessment, toxicity assessment, and risk characterization. Probabilistic risk assessment techniques may be recommended to provide risk managers with a more comprehensive understanding of the uncertainty associated with the quantitative risk assessment results. The following subsections present an overview of uncertainties that may be addressed in a site-specific risk assessment uncertainty section.

1.5.1 Uncertainty in Data Evaluation

This section may discuss uncertainties in the risk assessment associated with the analytical data and data quality. This may also involve a discussion of uncertainty in the COPC selection process, the inclusion or exclusion of COPCs in the risk assessment on the basis of background concentrations, the uncertainty in COPC screening levels, uncertainty associated with non-detected results that exceed the screening criteria, and the omission of constituents for which health criteria are not available.

1.5.2 Uncertainty in the Exposure Assessment

This section will include a discussion of the following: assumptions related to current and future land use; the uncertainty in EPCs (e.g., the use of maximum concentrations to estimate risks); uncertainty in the selection of potential receptors and exposure scenarios; and uncertainty in the selection of exposure parameters (RME vs. CTE). If predictive models are used in the risk estimation, the uncertainty associated with the model and modeling parameters will be evaluated.

1.5.3 Uncertainty in the Toxicity Assessment

The uncertainties inherent in RfDs and CSFs and use of available criteria will be discussed. A discussion of the uncertainty in hazard assessment, which deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will also

induce adverse effects in humans, will be provided. This section will also discuss uncertainty in the dose-response evaluations for the COPCs, which relates to the determination of a CSF for the carcinogenic assessment and derivation of an RfD for the non-carcinogenic assessment.

1.5.4 Uncertainty in the Risk Characterization

This section will discuss the uncertainty in risk characterization which results primarily from assumptions made regarding additivity/synergism of effects from exposure to multiple COPCs affecting different target organs across various exposure routes. The risk assessment will discuss the uncertainty inherent in summing risks for several substances across different exposure pathways. It should be noted that probabilistic risk assessment techniques may also be recommended to further define the uncertainty attached to the risk characterization results. However, the exposure assumptions (e.g., probability distributions) used to prepare the probabilistic risk assessment will be reviewed with the regulatory reviewers before they are incorporated into the uncertainty section of the baseline risk assessment.

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VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE - TRESPASSER - SOILS
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Trespasser	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	(1)	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	45	days/year	Professional Judgement	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Trespasser	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	45	days/year	Professional Judgement	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Notes:

1 - Same as adult resident exposures.

2 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

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Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 30) = 6.04E-08 Cancer Dermal Intake (Age 6 - 30) = 2.41E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 2.52E-08 Cancer Dermal Intake (Age 6 - 16) = 1.00E-07

Cancer Ingestion Intake Age (16 - 30) = 3.52E-08 Cancer Dermal Intake (Age 16 - 30) = 1.41E-07

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.76E-07 Noncancer Dermal Intake = 7.03E-07

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES - ADULT TRESPASSERS - SOILS
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Trespasser	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	(1)	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	25	days/year	Professional Judgement	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Trespasser	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	25	days/year	Professional Judgement	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

1 - Same as adult resident exposures.

2 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

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Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 1.40E-09 Cancer Dermal Intake = 1.59E-09

Noncancer Ingestion Intake = 1.40E-08 Noncancer Dermal Intake = 1.59E-08

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT TRESPASSERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Trespasser	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	2	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	45	days/year	Professional Judgement	AT x 24 hours/day
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1989, 2005	CA = (1/PEF + 1/VF) x Cs
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8760	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

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USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 30) = 3.52E-03

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 1.03E-02

Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 16) = 1.47E-03

Cancer Inhalation Intake (Age 16 - 30) = 2.05E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT TRESPASSER - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Trespasser	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	2	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	25	days/year	MEDEP, 2009	AT x 24 hours/day
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	2555	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 5.71E-04

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 5.71E-03

Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 16) = 1.63E-04

Cancer Inhalation Intake (Age 16 - 30) = 4.08E-04

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT TRESPASSERS - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Trespasser	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CSx IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	(1)	BW x AT
				EF	Exposure Frequency	45	days/year	(1)	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Trespasser	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	45	days/year	(1)	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - Adults will be evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, adult recreational users will be evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 30) = 6.04E-08 Cancer Dermal Intake (Age 6 - 30) = 2.41E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 2.52E-08 Cancer Dermal Intake (Age 6 - 16) = 1.00E-07

Cancer Ingestion Intake (Age 16 - 30) = 3.52E-08 Cancer Dermal Intake (Age 16 - 30) = 1.41E-07

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.76E-07 Noncancer Dermal Intake = 7.03E-07

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT TRESPASSER - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Trespasser	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	(1)	BW x AT
				EF	Exposure Frequency	25	days/year	(1)	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Trespasser	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	25	days/year	(1)	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - Adults will be evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, adult recreational users will be evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 4.89E-09 Cancer Dermal Intake = 5.58E-09

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 1.40E-09 Cancer Dermal Intake (Age 6 - 16) = 1.59E-09

Cancer Ingestion Intake (Age 16 - 30) = 3.49E-09 Cancer Dermal Intake (Age 16 - 30) = 3.98E-09

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 4.89E-08 Noncancer Dermal Intake = 5.58E-08

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CONSTRUCTION WORKERS - SOILS

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Construction Workers	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	330	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	250	days/year	MEDEP, 2009	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
Dermal	Construction Workers	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.3	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	250	days/year	MEDEP, 2009	
				ED	Exposure Duration	1	years	MEDEP, 2009	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 4.61E-08 Cancer Dermal Intake = 1.38E-07

Noncancer Ingestion Intake = 3.23E-06 Noncancer Dermal Intake = 9.69E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CONSTRUCTION WORKERS - SOILS

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Construction Workers	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	165	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	150	days/year	(1)	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
Dermal	Construction Workers	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	150	days/year	(1)	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	

Notes:

1. Professional judgement. Values are 50 percent of RME.

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPAb, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 1.38E-08 Cancer Dermal Intake = 2.77E-08

Noncancer Ingestion Intake = 9.69E-07 Noncancer Dermal Intake = 1.94E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CONSTRUCTION WORKERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Construction Workers	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	8	hours/day	MEDEP, 2009	CA x ET x EF x ED
				CF	Conversion Factor	24	hours/day	--	AT x CF
				EF	Exposure Frequency	250	days/year	MEDEP, 2009	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.43E+06	m3/kg	USEPA, 2002a	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

Unit Intake Calculations

Inhalation Intake = (ET x EF x ED)/(AT x CF)

Cancer Inhalation Intake = 3.26E-03 Noncancer Inhalation Intake = 2.28E-01

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CONSTRUCTION WORKERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Construction Workers	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	8	hours/day	MEDEP, 2009	CA x ET x EF x ED
				CF	Conversion Factor	24	hours/day	--	AT x CF
				EF	Exposure Frequency	150	days/year	(1)	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
				PEF	Particulate Emission Factor	1.43E+06	m3/kg	USEPA, 2002a	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	

Notes:

1. Professional judgement. Values are 50 percent of RME.

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

Unit Intake Calculations

Inhalation Intake = (ET x EF x ED)/(AT x CF)

Cancer Inhalation Intake = 1.96E-03 Noncancer Inhalation Intake = 1.37E-01

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

Footnote:

1 Site specific value for construction worker; assumes 140 days of precipitation > 0.01 inches (USEPA, 2002a).

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CONSTRUCTION WORKERS - GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Construction Workers	Adult	Site 12	CGW	Chemical Concentration in Groundwater	Max or 95% UCL	ug/L	USEPA, 2002a	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	0.05	L/day	(1)	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	30	days/year	(1)	BW x AT
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 2002	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
Dermal	Construction Workers	Adult	Site 12	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				Cw	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002a	
				FA	Fraction Absorbed	Chemical Specific	unitless	USEPA, 2004	DAevent x EV x EF x ED x SA
				CF	Conversion factor	0.001	L/cm^3	- -	BW x AT
				Kp	Permeability coefficient	Chemical Specific	cm/hr	USEPA, 2004	
				τ	Lag time	Chemical Specific	hr/event	USEPA, 2004	For inorganics
				t*	Time it takes to reach steady state	Chemical Specific	hr/event	USEPA, 2004	DAevent = Kp x CW x CF x tevent
				tevent	Duration of event	4	hr/event	(1)	
				B	Bunge model constant	Chemical Specific	unitless	USEPA, 2004	For organics if tevent <= t*
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	DAevent= 2 x FA x Kp x Cw x CF x sqrt[(6 x τ x tevent)/pi]
				EV	Event Frequency	1	events/day	(1)	
				EF	Exposure Frequency	30	days/year	(1)	For organics if tevent > t*
				ED	Exposure Duration	1	years	USEPA, 2002b	DAevent =FA x Kp x Cw x CF x [tevent/(1+B) +
				BW	Body Weight	70	kg	USEPA, 2002b	2 x τ +(1 + 3B + $3B^2$)/(1+B^2)
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	See Section 6.2.3.5 for discussion of methodology.

Notes:

1 - Professional judgment. Assumes construction workers are only exposed to groundwater water during part of the contruction project.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002a:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Cancer Dermal Intake = 5.54E-02 Noncancer Dermal Intake = 3.87E+00

Cancer risk from dermal contact = Groundwater concentration x Cancer Dermal Intake x DAevent x Dermal Cancer Slope Factor

Hazard Index from dermal contact = Groundwater concentration x Noncancer Dermal Intake x DAevent / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CONSTRUCTION WORKERS - GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Construction Workers	Adult	Site 12	CGW	Chemical Concentration in Groundwater	Max or 95% UCL	ug/L	USEPA, 2002a	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	0.025	L/day	(1)	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	15	days/year	(1)	BW x AT
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
Dermal	Construction Workers	Adult	Site 12	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				Cw	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002a	
				FA	Fraction Absorbed	Chemical Specific	unitless	USEPA, 2004	DAevent x EV x EF x ED x SA
				CF	Conversion factor	0.001	L/cm3	- -	BW x AT
				Kp	Permeability coefficient	Chemical Specific	cm/hr	USEPA, 2004	
				τ	Lag time	Chemical Specific	hr/event	USEPA, 2004	For inorganics
				t*	Time it takes to reach steady state	Chemical Specific	hr/event	USEPA, 2004	DAevent = Kp x CW x CF x tevent
				tevent	Duration of event	2	hr/event	(1)	
				B	Bunge model constant	Chemical Specific	unitless	USEPA, 2004	For organics if tevent <= t*
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	DAevent= 2 x FA x Kp x Cw x CF x sqrt[(6 x τ x tevent)/pi]
				EV	Event Frequency	1	events/day	(1)	
				EF	Exposure Frequency	15	days/year	(1)	For organics if tevent > t*
				ED	Exposure Duration	1	years	USEPA, 2002b	DAevent =FA x Kp x Cw x CF x [tevent/(1+B) +
				BW	Body Weight	70	kg	USEPA, 2002b	2 x τ +(1 + 3B + $3B^2$)/(1+B^2)
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	See Section 6.2.3.5 for discussion of methodology.

Notes:

1 - Professional judgment. Assumes construction workers are only exposed to groundwater water during part of the contruction project. Values are 50 percent of RME.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Cancer Dermal Intake = 2.77E-02 Noncancer Dermal Intake = 1.94E+00

Cancer risk from dermal contact = Groundwater concentration x Cancer Dermal Intake x DAevent x Dermal Cancer Slope Factor

Hazard Index from dermal contact = Groundwater concentration x Noncancer Dermal Intake x DAevent / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CONSTRUCTION WORKERS - GROUNDWATER TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Construction Workers	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	VDEQ, 2004	Exposure Concentration (mg/m^3) =
				CW	Chemical concentration in water	Max or 95% UCL	ug/L	--	
				CF	Conversion Factor	0.001	mg/ug	--	CA x ET x EF x ED
				ET	Exposure Time	4	hours/day	(1)	AT x 24 hours/day
				EF	Exposure Frequency	30	days/year	(1)	
				ED	Exposure Duration	1	years	(1)	CA = CW x CF x VF
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
				VF	Volatilization Factor	Calculated	(mg/m3)/(mg/L)	VDEQ, 2004	

Notes:

1 - Professional judgment.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

VDEQ, 2004: Virginia Department of Environmental Quality (VDEQ, online- http://www.deq.state.va.us/vrprisk/homepage.html).

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 1.96E-07 Noncancer Inhalation Intake = 1.37E-05

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CONSTRUCTION WORKERS - GROUNDWATER TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Construction Workers	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	VDEQ, 2004	Exposure Concentration (mg/m^3) =
				CW	Chemical concentration in water.	Max or 95% UCL	ug/L	--	
				CF	Conversion Factor	0.001	mg/ug	--	CA x ET x EF x ED
				ET	Exposure Time	2	hours/day	(1)	AT x 24 hours/day
				EF	Exposure Frequency	15	days/year	(1)	
				ED	Exposure Duration	1	years	(1)	CA = CW x CF x VF
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
				VF	Volatilization Factor	Calculated	(mg/m3)/(mg/L)	VDEQ, 2004	

Notes:

1 - Professional judgment. For some factors, CTE is assumed to be 50 percent of RME.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

VDEQ, 2004: Virginia Department of Environmental Quality (VDEQ, online- http://www.deq.state.va.us/vrprisk/homepage.html).

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 4.89E-08 Noncancer Inhalation Intake = 3.42E-06

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CONSTRUCTION WORKERS - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Construction Workers	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	330	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CSx IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.5	unitless	(1)	BW x AT
				EF	Exposure Frequency	30	days/year	(1)	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
Dermal	Construction Workers	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.3	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	30	days/year	(1)	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	

Notes:

1 - Professional judgment. Assumes construction workers are only exposed to sediment during part of the construction project.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 2.77E-09 Cancer Dermal Intake = 1.66E-08

Noncancer Ingestion Intake = 1.94E-07 Noncancer Dermal Intake = 1.16E-06

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CONSTRUCTION WORKERS - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Construction Workers	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	330	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.5	unitless	(1)	BW x AT
				EF	Exposure Frequency	15	days/year	(2)	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	
Dermal	Construction Workers	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2002b	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.1	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	15	days/year	(2)	
				ED	Exposure Duration	1	years	USEPA, 2002b	
				BW	Body Weight	70	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	365	days	USEPA, 1989	

Notes:

1 - Professional judgment. Receptor is only at the site part of the day.

2 - Professional judgment. Assumes construction workers are only exposed to sediment during part of the construction project. Values are 50 percent of RME.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 1.38E-09 Cancer Dermal Intake = 2.77E-09

Noncancer Ingestion Intake = 9.69E-08 Noncancer Dermal Intake = 1.94E-07

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - OCCUPATIONAL WORKERS - SOIL

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Occupational Worker	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	--	--	BW x AT
				EF	Exposure Frequency	150	days/year	MEDEP, 2009	
				ED	Exposure Duration	25	years	USEPA, 1997	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9125	days	USEPA, 1989	
Dermal	Occupational Worker	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	150	days/year	MEDEP, 2009	
				ED	Exposure Duration	25	years	USEPA, 1993	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	9125	days	USEPA, 1989	

Sources:

MEDEP, 2009. Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1993. Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C. May.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 2.10E-07 Cancer Dermal Intake = 1.38E-06

Noncancer Ingestion Intake = 5.87E-07 Noncancer Dermal Intake = 3.87E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - OCCUPATIONAL WORKERS - SOIL

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Occupational Worker	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	75	days/year	(1)	
				ED	Exposure Duration	9	years	USEPA, 1993	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3285	days	USEPA, 1989	
Dermal	Occupational Worker	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	3300	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.02	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	75	days/year	(1)	
				ED	Exposure Duration	9	years	USEPA, 1993	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	3285	days	USEPA, 1989	

Notes:

1. Professional judgement. Values are 50 percent of RME.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. OERR. EPA/540/1-89/002.

USEPA, 1993: Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C. May.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 1.89E-08 Cancer Dermal Intake = 2.49E-08

Noncancer Ingestion Intake = 1.47E-07 Noncancer Dermal Intake = 1.94E-07

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - OCCUPATIONAL WORKERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Industrial Workers	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	8	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	150	days/year	MEDEP, 2009	AT x 24 hours/day
				ED	Exposure Duration	25	years	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	9125	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2012	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA, 2012	

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental guidance: Standard Default Exposure Factors, March 1991.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 4.89E-02 Noncancer Inhalation Intake = 1.37E-01

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - OCCUPATIONAL WORKERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Current/Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Industrial Workers	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	8	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	75	days/year	(1)	AT x 24 hours/day
				ED	Exposure Duration	9	years	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	3285	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1. Professional judgement. Values are 50 percent of RME.

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 8.81E-03 Noncancer Inhalation Intake = 6.85E-02

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE - CHILD RECREATIONAL USERS - SOILS
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	200	mg/day	USEPA, 1997	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2190	days	USEPA, 1989	
Dermal	Recreational User	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2190	days	USEPA, 1989	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 6) = 2.82E-07 Cancer Dermal Intake (Age 0 - 6) = 7.89E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 9.39E-08 Cancer Dermal Intake (Age 0 - 2) = 2.63E-07

Cancer Ingestion Intake (Age 2 - 6) = 1.88E-07 Cancer Dermal Intake (Age 2 - 6) = 5.26E-07

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 3.29E-06 Noncancer Dermal Intake = 9.21E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES - CHILD RECREATIONAL USERS - SOILS
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface Soil/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1997	
				CF3	Conversion Factor 3	0.000001	kg/mg	--	CSs x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
Dermal	Recreational User	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	0.000001	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.04	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 4.70E-08 Cancer Dermal Intake = 5.26E-08

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 2.35E-08 Cancer Dermal Intake (Age 0 - 2) = 2.63E-08

Cancer Ingestion Intake (Age 2 - 6) = 2.35E-08 Cancer Dermal Intake (Age 2 - 6) = 2.63E-08

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.64E-06 Noncancer Dermal Intake = 1.84E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CHILD RECREATIONAL USERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Child	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	2	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	AT x 24 hours/day
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	CA = (1/PEF + 1/VF) x Cs
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 6) = 1.76E-03

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 2.05E-02

Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 2) = 5.87E-04

Cancer Inhalation Intake (Age 2 - 6) = 1.17E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CHILD RECREATIONAL USERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Child	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	2	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	AT x 24 hours/day
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA 2010	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 5.87E-04

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 2.05E-02

Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 2) = 2.94E-04

Cancer Inhalation Intake (Age 2 - 6) = 2.94E-04

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CHILD RECREATIONAL USERS - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	200	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	(1)	BW x AT
				EF	Exposure Frequency	30	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	
Dermal	Recreational User	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	(3), USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	30	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, children recreational users will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

3 - 95th Percentile value for a child playing in wet soil, Exhibit 3-3, USEPA 2004.

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 6) = 9.39E-08 Cancer Dermal Intake (Age 0 - 6) = 2.63E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 3.13E-08 Cancer Dermal Intake (Age 0 - 2) = 8.77E-08

Cancer Ingestion Intake (Age 2 - 6) = 6.26E-08 Cancer Dermal Intake (Age 2 - 6) = 1.75E-07

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.10E-06 Noncancer Dermal Intake = 3.07E-06

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CHILD RECREATIONAL USERS - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	(1)	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	USEPA, 1993	BW x AT
				EF	Exposure Frequency	30	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
Dermal	Recreational User	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.04	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	30	days/year	(1)	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, children recreational users will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 1.57E-08 Cancer Dermal Intake = 1.75E-08

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 7.83E-09 Cancer Dermal Intake (Age 0 - 2) = 8.77E-09

Cancer Ingestion Intake (Age 2 - 6) = 7.83E-09 Cancer Dermal Intake (Age 2 - 6) = 8.77E-09

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 5.48E-07 Noncancer Dermal Intake = 6.14E-07

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RECREATIONAL USERS - SOILS

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	(1)	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Recreational User	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Notes:

1 - Same as adult resident exposures.

2 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 30) = 1.21E-07 Cancer Dermal Intake (Age 6 - 30) = 4.82E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 5.03E-08 Cancer Dermal Intake (Age 6 - 16) = 2.01E-07

Cancer Ingestion Intake Age (16 - 30) = 7.05E-08 Cancer Dermal Intake (Age 16 - 30) = 2.81E-07

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 3.52E-07 Noncancer Dermal Intake = 1.41E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT RECREATIONAL USERS - SOILS

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	(1)	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Recreational User	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1)(2)	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1)(2)	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

1 - Same as adult resident exposures.

2 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 5.03E-09 Cancer Dermal Intake = 5.74E-09

Noncancer Ingestion Intake = 5.03E-08 Noncancer Dermal Intake = 5.74E-08

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RECREATIONAL USERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	2	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	AT x 24 hours/day
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1989, 2005	CA = (1/PEF + 1/VF) x Cs
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8760	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 30) = 7.05E-03

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 2.05E-02

Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 16) = 2.94E-03

Cancer Inhalation Intake (Age 16 - 30) = 4.11E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT RECREATIONAL USERS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Recreational User	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	2	hours/day	MEDEP, 2009	CA x ET x EF x ED
				EF	Exposure Frequency	90	days/year	MEDEP, 2009	AT x 24 hours/day
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	2555	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, recreational adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 2.05E-03

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 2.05E-02

Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 16) = 5.87E-04

Cancer Inhalation Intake (Age 16 - 30) = 1.47E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RECREATIONAL USERS - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1991	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CSx IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	(1)	BW x AT
				EF	Exposure Frequency	78	days/year	MDE, 2009	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Recreational User	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	78	days/year	MDE, 2009	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - Adults will be evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, adult recreational users will be evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

MEDEP, 2009: Guidance for Human Health Risk Assessment for Hazardous Substance Sites in Maine. DEP-BRWM 2B 2009, July.

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 30) = 1.05E-07 Cancer Dermal Intake (Age 6 - 30) = 4.18E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 4.36E-08 Cancer Dermal Intake (Age 6 - 16) = 1.74E-07

Cancer Ingestion Intake (Age 16 - 30) = 6.11E-08 Cancer Dermal Intake (Age 16 - 30) = 2.44E-07

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 3.05E-07 Noncancer Dermal Intake = 1.22E-06

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT RECREATIONAL USERS - SEDIMENT

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Recreational User	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	(1)	BW x AT
				EF	Exposure Frequency	78	days/year	MDE, 2009	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1989	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Recreational User	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	78	days/year	MDE, 2009	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(2), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(2), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

Notes:

1 - Professional judgment.

2 - Adults will be evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, adult recreational users will be evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

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USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 1.53E-08 Cancer Dermal Intake = 1.74E-08

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 4.36E-09 Cancer Dermal Intake (Age 6 - 16) = 4.97E-09

Cancer Ingestion Intake (Age 16 - 30) = 1.09E-08 Cancer Dermal Intake (Age 16 - 30) = 1.24E-08

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.53E-07 Noncancer Dermal Intake = 1.74E-07

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE - CHILD RESIDENTS - SOILS
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	200	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	Assumed	BW x AT
				EF	Exposure Frequency	350	days/year	USEPA, 2002b	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	
Dermal	Residents	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2002b	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 6) = 1.10E-06 Cancer Dermal Intake (Age 0 - 6) = 3.07E-06

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 3.65E-07 Cancer Dermal Intake (Age 0 - 2) = 1.02E-06

Cancer Ingestion Intake (Age 2 - 6) = 7.31E-07 Cancer Dermal Intake (Age 2 - 6) = 2.05E-06

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.28E-05 Noncancer Dermal Intake = 3.58E-05

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES - CHILD RESIDENTS - SOILS
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	Assumed	BW x AT
				EF	Exposure Frequency	234	days/year	USEPA, 1993	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
Dermal	Residents	Child	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.04	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	234	days/year	USEPA, 1993	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1993. Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C. May.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 6.11E-08 Cancer Dermal Intake = 6.84E-08

Noncancer Ingestion Intake = 2.14E-06 Noncancer Dermal Intake = 2.39E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CHILD RESIDENTS SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Child	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	USEPA, 2002a	CA x ET x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 2002a	AT x 24 hours/day
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	CA = (1/PEF + 1/VF) x Cs
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2190	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 6) = 8.22E-02

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 9.59E-01

Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 2) = 2.74E-02

Cancer Inhalation Intake (Age 2 - 6) = 5.48E-02

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CHILD RESIDENTS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Child	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	USEPA, 2002a	CA x ET x EF x ED
				EF	Exposure Frequency	234	days/year	USEPA, 2002a	AT x 24 hours/day
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals

Cancer Inhalation Intake = 1.83E-02

Noncarcinogenic Chemicals

Noncancer Inhalation Intake = 6.41E-01

Mutagenic Chemicals

Cancer Inhalation Intake (Age 0 - 2) = 9.16E-03

Cancer Inhalation Intake (Age 2 - 6) = 9.16E-03

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CHILD RESIDENTS - GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Child	Site 12	CGW	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002a	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	1	L/day	USEPA, 1991	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 1991	BW x AT
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	
Dermal	Residents	Child	Site 12	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				Cw	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002a	
				FA	Fraction Absorbed	Chemical Specific	unitless	USEPA, 2004	DAevent x EV x EF x ED x SA
				CF	Conversion factor	0.001	L/cm3	- -	BW x AT
				Kp	Permeability coefficient	Chemical Specific	cm/hr	USEPA, 2004	
				τ	Lag time	Chemical Specific	hr/event	USEPA, 2004	For inorganics
				t*	Time it takes to reach steady state	Chemical Specific	hr/event	USEPA, 2004	DAevent = Kp x CW x CF x tevent
				tevent	Duration of event	1	hr/event	USEPA, 2004	
				B	Bunge model constant	Chemical Specific	unitless	USEPA, 2004	For organics if tevent <= t*
				SA	Skin Surface Available for Contact	6,600	cm2	USEPA, 2004	DAevent= 2 x FA x Kp x Cw x CF x sqrt[(6 x τ x tevent)/pi]
				EV	Event Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2004	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	DAevent =FA x Kp x Cw x CF x [tevent/(1+B) +
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	2 x τ +(1 + 3B + $3B^2$)/(1+B^2)
				BW	Body Weight	15	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	See Section 6.2.3.5 for discussion of methodology.
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 6) = 5.48E-06 Cancer Dermal Intake Time (Age 0 - 6) = 3.62E+01

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 1.83E-06 Cancer Dermal Intake (Age 0 - 2) = 1.21E+01

Cancer Ingestion Intake (Age 2 - 6) = 3.65E-06 Cancer Dermal Intake (Age 2 - 6) = 2.41E+01

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 6.39E-05 Noncancer Dermal Intake = 4.22E+02

Cancer risk from ingestion = Groundwater concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Groundwater concentration x Cancer Dermal Intake x DAevent x Dermal Cancer Slope Factor

Hazard Index from ingestion = Groundwater concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Groundwater concentration x Noncancer Dermal Intake x DAevent / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - CHILD RESIDENTS - GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Child	Site 12	CGW	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	0.74	L/day	USEPA, 1997	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 2004	BW x AT
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1993, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1993, 2005	
				BW	Body Weight	15	years	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
Dermal	Residents	Child	Site 12	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				Cw	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002	
				FA	Fraction Absorbed	Chemical Specific	unitless	USEPA, 2004	DAevent x EV x EF x ED x SA
				CF	Conversion factor	0.001	L/cm3	- -	BW x AT
				Kp	Permeability coefficient	Chemical Specific	cm/hr	USEPA, 2004	
				τ	Lag time	Chemical Specific	hr/event	USEPA, 2004	For inorganics
				t*	Time it takes to reach steady state	Chemical Specific	hr/event	USEPA, 2004	DAevent = Kp x CW x CF x tevent
				tevent	Duration of event	0.33	hr/event	USEPA, 2004	
				B	Bunge model constant	Chemical Specific	unitless	USEPA, 2004	For organics if tevent <= t*
				SA	Skin Surface Available for Contact	6,600	cm2	USEPA, 2004	DAevent= 2 x FA x Kp x Cw x CF x sqrt[(6 x τ x tevent)/pi]
				EV	Event Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2004	For organics if tevent > t*
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1993, 2005	DAevent =FA x Kp x Cw x CF x [tevent/(1+B) +
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1993, 2005	2 x τ +(1 + 3B + $3B^2$)/(1+B^2)
				BW	Body Weight	15	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	See Section 6.2.3.5 for discussion of methodology.
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	

Notes:

1 - Children were evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children were evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 1.35E-06 Cancer Dermal Intake = 1.21E+01

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 6.76E-07 Cancer Dermal Intake (Age 0 - 2) = 6.03E+00

Cancer Ingestion Intake (Age 2 - 6) = 6.76E-07 Cancer Dermal Intake (Age 2 - 6) = 6.03E+00

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 4.73E-05 Noncancer Dermal Intake = 4.22E+02

Cancer risk from ingestion = Groundwater concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Groundwater concentration x Cancer Dermal Intake x DAevent x Dermal Cancer Slope Factor

Hazard Index from ingestion = Groundwater concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Groundwater concentration x Noncancer Dermal Intake x DAevent / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - CHILD RESIDENTS - INHALATION OF VOLATILES FROM GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Residents	Child	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 1991	Exposure Concentration (mg/m^3) =
				GW	Chemical concentration in water.	95% UCL or Max	ug/L	USEPA, 2002	
				CF	Conversion Factor	0.001	mg/ug	--	CA x ET x EF x ED
				ET	Exposure Time	24	hours/day	USEPA, 1991	AT x 24 hours/day
				EF	Exposure Frequency	350	days/year	USEPA, 1991	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(1), USEPA, 1989, 2005	CA = CW x CF x VF
				ED2	Exposure Duration (Age 2 - 6)	4	years	(1), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1997	
				AT-N	Averaging Time (Non-Cancer)	2190	days	USEPA, 1989	
				VF	Volatilization Factor	0.5	L/m3	USEPA, 1989	

Notes:

1 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals. OSWER Directive 9285.7-01B.

USEPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 2.74E-05 Noncancer Inhalation Intake = 3.20E-04

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE - CHILD RESIDENTS - INHALATION OF VOLATILES FROM GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Residents	Child	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 1991	Exposure Concentration (mg/m^3) =
				GW	Chemical concentration in water.	95% UCL or Max	ug/L	USEPA, 2002	
				CF	Conversion Factor	0.001	mg/ug	--	CA x ET x EF x ED
				ET	Exposure Time	24	hours/day	USEPA, 1991	AT x 24 hours/day
				EF	Exposure Frequency	350	days/year	USEPA, 2004	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(1), USEPA, 1993, 2005	CA = CW x CF x VF
				ED2	Exposure Duration (Age 2 - 6)	1	years	(1), USEPA, 1993, 2005	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1997	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
				VF	Volatilization Factor	0.5	L/m3	USEPA, 1989	

Notes:

1 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals. OSWER Directive 9285.7-01B.

USEPA, 1997: Exposure Factors Handbook. EPA/600/P-95/002Fa

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 1.37E-05 Noncancer Inhalation Intake = 4.79E-04

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE - CHILD RESIDENTS - SEDIMENT
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	200	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.5	unitless	(1)	BW x AT
				EF	Exposure Frequency	24	days/year	(2)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(3), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(3), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	
Dermal	Resident	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	24	days/year	(2)	
				ED1	Exposure Duration (Age 0 - 2)	2	years	(3), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 2 - 6)	4	years	(3), USEPA, 1989, 2005	
				BW	Body Weight	15	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,190	days	USEPA, 1989	

Notes:

1 - Professional judgment. Receptor is only at the site part of the day.

2 - Assumes one hour a day for one day a week for 24 weeks during late spring, summer, and early fall.

3 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 6) = 3.76E-08 Cancer Dermal Intake (Age 0 - 6) = 2.10E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 1.25E-08 Cancer Dermal Intake (Age 0 - 2) = 7.01E-08

Cancer Ingestion Intake (Age 2 - 6) = 2.50E-08 Cancer Dermal Intake (Age 2 - 6) = 1.40E-07

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 4.38E-07 Noncancer Dermal Intake = 2.45E-06

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES - CHILD RESIDENTS - SEDIMENT
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Resident	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	- -	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.5	unitless	(1)	BW x AT
				EF	Exposure Frequency	12	days/year	(2)	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(2), USEPA, 1993, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(2), USEPA, 1993, 2005	
				BW	Body Weight	15	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	
Dermal	Resident	Child	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	2,800	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.2	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	12	days/year	(2)	
				ED1	Exposure Duration (Age 0 - 2)	1	years	(2), USEPA, 1993, 2005	
				ED2	Exposure Duration (Age 2 - 6)	1	years	(2), USEPA, 1993, 2005	
				BW	Body Weight	15	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	730	days	USEPA, 1989	

Notes:

1 - Professional judgment. Receptor is only at the site part of the day.

2 - Assumes one day every other week during the late spring, summer, and early fall months (50 perecnt of RME).

3 - Children will be evaluated as one age group (0 - 6 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential children will be evaluated as two age groups, 0 - 2 years and 2 - 6 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 3.13E-09 Cancer Dermal Intake = 3.51E-08

Mutagenic Chemicals

Cancer Ingestion Intake (Age 0 - 2) = 1.57E-09 Cancer Dermal Intake (Age 0 - 2) = 1.75E-08

Cancer Ingestion Intake (Age 2 - 6) = 1.57E-09 Cancer Dermal Intake (Age 2 - 6) = 1.75E-08

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.10E-07 Noncancer Dermal Intake = 1.23E-06

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RESIDENTS - SOILS

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	350	days/year	USEPA, 2002b	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Residents	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2002b	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Notes:

1 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a:Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 30) = 4.70E-07 Cancer Dermal Intake (Age 6 - 30) = 1.87E-06

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 1.96E-07 Cancer Dermal Intake (Age 6 - 16) = 7.81E-07

Cancer Ingestion Intake (Age 16 - 30) = 2.74E-07 Cancer Dermal Intake (Age 16 - 30) = 1.09E-06

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.37E-06 Noncancer Dermal Intake = 5.47E-06

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES - ADULT RESIDENTS - SOILS
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Surface/Subsurface Soil

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	1	unitless	--	BW x AT
				EF	Exposure Frequency	234	days/year	USEPA, 1993	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Residents	Adult	Site 12	CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002a	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.01	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	234	days/year	USEPA, 1993	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1989, 2005	
				BW	Body Weight	70	kg	USEPA, 1997	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

1 - Adults were evaluated as one age group (6 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults were evaluated as two age groups, 6 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A.

USEPA, 1993: Distribution of Preliminary Review Draft: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure. Office of Solid Waste and Emergency Response, Washington, D.C. May.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Cancer Ingestion Intake = 1.31E-08 Cancer Dermal Intake = 1.49E-08

Noncancer Ingestion Intake = 1.31E-07 Noncancer Dermal Intake = 1.49E-07

Cancer risk from ingestion = Soil concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Soil concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Soil concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Soil concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RESIDENTS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	USEPA, 2002a	CA x ET x EF x ED / AT x 24 hours/day
				EF	Exposure Frequency	350	days/year	USEPA, 2002a	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1989, 2005	CA = (1/PEF + 1/VF) x Cs
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8760	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	$PEF = \frac{Q / C \times 3600}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	$F(x) = 0.18 * (8x^3 + 12x) * \exp(-x^2)$
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	x = 0.886 * Ut / Um
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Adults were evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults were evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals		Noncarcinogenic Chemicals	
Cancer Inhalation Intake (Age 6 - 30) =	3.29E-01	Noncancer Inhalation Intake =	9.59E-01

Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 16) = 1.37E-01

Cancer Inhalation Intake (Age 16 - 30) = 1.92E-01

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT RESIDENTS - SOILS TO AIR

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Surface/Subsurface Soil
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Resident	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 2002a	Exposure Concentration (mg/m^3) =
				CS	Chemical concentration in soil	Max or 95% UCL	mg/kg	USEPA, 2002b	
				ET	Exposure Time	24	hours/day	USEPA, 2002a	CA x ET x EF x ED / AT x 24 hours/day
				EF	Exposure Frequency	234	days/year	USEPA, 2002b	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1989, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	CA = (1/PEF + 1/VF) x Cs
				AT-N	Averaging Time (Non-Cancer)	2555	days	USEPA, 1989	
				PEF	Particulate Emission Factor	9.37E+09	m3/kg	USEPA, 2012	$PEF = \frac{Q / C \times 3600}{0.036 \times (1 - V) \times (U_m / U_t)^3 \times F(x)}$
				VF	Volatilization Factor	Chemical-specific	m3/kg	USEPA, 2002a	
				Q/C	Inverse of mean concentration at center of source	74.3185	g/m2-s per kg/m3	USEPA, 2012	
				Ut	Equivalent threshold of wind velocity at 7m.	11.32	m/sec	USEPA, 2012	
				Um	Mean annual wind speed	3.89	m/sec	USEPA, 2012	x = 0.886 * Ut / Um
				V	Fraction of vegetative cover	0.5	unitless	USEPA, 2012	
				F(x)	Function dependent of Um/Ut	0.0391	unitless	USEPA 2012	

Notes:

1 - Adults were evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults were evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. USEPA/540/1-86/060.

USEPA, 2002a: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2002b: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2012: Soil Screening Guidance calculation Internet site at http://rais.ornl.gov/cgi-bin/epa/ssl1.cgi. Site-specific values for Portland, Maine.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Non-Mutagenic Chemicals	Noncarcinogenic Chemicals
Cancer Inhalation Intake = 6.41E-02	Noncancer Inhalation Intake = 6.41E-01

Mutagenic Chemicals

Cancer Inhalation Intake (Age 6 - 16) = 1.83E-02

Cancer Inhalation Intake (Age 16 - 30) = 4.58E-02

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RESIDENTS - GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 12	CGW	Chemical Concentration in Groundwater	95% UCL or Max	ug/L	USEPA, 2002	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	2	L/day	USEPA, 1991	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 2004	BW x AT
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1991, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1991, 2005	
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Residents	Adult	Site 12	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				Cw	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002	DAevent x EV x EF x ED x SA
				FA	Fraction Absorbed	Chemical Specific	unitless	USEPA, 2004	BW x AT
				CF	Conversion factor	0.001	L/cm3	- -	
				Kp	Permeability coefficient	Chemical Specific	cm/hr	USEPA, 2004	For inorganics
				τ	Lag time	Chemical Specific	hr/event	USEPA, 2004	DAevent = Kp x CW x CF x tevent
				t*	Time it takes to reach steady state	Chemical Specific	hr/event	USEPA, 2004	
				tevent	Duration of event	0.58	hr/event	(1)	For organics if tevent <= t*
				B	Bunge model constant	Chemical Specific	unitless	USEPA, 2004	DAevent= 2 x FA x Kp x Cw x CF x sqrt[(6 x τ x tevent)/pi]
				SA	Skin Surface Available for Contact	18,000	cm2	USEPA, 2004	
				EV	Event Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2004	For organics if tevent > t*
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1991, 2005	DAevent =FA x Kp x Cw x CF x [tevent/(1+B) +
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1991, 2005	2 x τ +(1 + 3B + $3B^2$)/(1+B^2)
				BW	Body Weight	70	kg	USEPA, 1991	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	See Section 6.2.3.5 for discussion of methodology.
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Notes:

1 - Adults were evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults were evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors. OSWER Directive 9285.6-03.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 30) = 9.39E-06 Cancer Dermal Intake (Age 6 - 30) = 8.45E+01

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 3.91E-06 Cancer Dermal Intake (Age 6 - 16) = 3.52E+01

Cancer Ingestion Intake (Age 16 - 30) = 5.48E-06 Cancer Dermal Intake (Age 16 - 30) = 4.93E+01

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 2.74E-05 Noncancer Dermal Intake = 2.47E+02

Cancer risk from ingestion = Groundwater concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Groundwater concentration x Cancer Dermal Intake x DAevent x Dermal Cancer Slope Factor

Hazard Index from ingestion = Groundwater concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Groundwater concentration x Noncancer Dermal Intake x DAevent / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURES - ADULT RESIDENTS - GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 12	CGW	Chemical Concentration in Groundwater	95% UCL or Max	ug/L	USEPA, 2002	Chronic Daily Intake (CDI) (mg/kg/day) =
				CF	Conversion Factor	0.001	mg/ug	--	
				IR-GW	Ingestion Rate of Groundwater	1.4	L/day	USEPA, 1993	CGW x CF x IR-GW x EF x ED
				EF	Exposure Frequency	350	days/year	USEPA, 2004	BW x AT
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1993, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1993, 2005	
				BW	Body Weight	70	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Residents	Adult	Site 12	Daevent	Dermally Absorbed Dose per Event	Calculated	mg/cm2-event	USEPA, 2004	Dermally Absorbed Dose (mg/kg/day) =
				Cw	Chemical Concentration in Groundwater	Max or 95% UCL	mg/L	USEPA, 2002a	
				FA	Fraction Absorbed	Chemical Specific	unitless	USEPA, 2004	DAevent x EV x EF x ED x SA
				CF	Conversion factor	0.001	L/cm3	- -	BW x AT
				Kp	Permeability coefficient	Chemical Specific	cm/hr	USEPA, 2004	
				τ	Lag time	Chemical Specific	hr/event	USEPA, 2004	For inorganics
				t*	Time it takes to reach steady state	Chemical Specific	hr/event	USEPA, 2004	DAevent = Kp x CW x CF x tevent
				tevent	Duration of event	0.25	hr/event	USEPA, 2004	
				B	Bunge model constant	Chemical Specific	unitless	USEPA, 2004	For organics if tevent <= t*
				SA	Skin Surface Available for Contact	18,000	cm2	USEPA, 2004	DAevent= 2 x FA x Kp x Cw x CF x sqrt[(6 x τ x tevent)/pi]
				EV	Event Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	350	days/year	USEPA, 2004	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1993, 2005	DAevent =FA x Kp x Cw x CF x [tevent/(1+B) +
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1993, 2005	2 x τ +(1 + 3B + $3B^2$)/(1+B^2)
				BW	Body Weight	70	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	See Section 6.2.3.5 for discussion of methodology.
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

Notes:

1 - Adults were evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults were evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1993: Superfund's Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Ingestion Intake = (IR-GW x EF x ED)/(BW x AT)

Dermal Intake = (SA x EV x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 1.92E-06 Cancer Dermal Intake = 2.47E+01

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 5.48E-07 Cancer Dermal Intake (Age 6 - 16) = 7.05E+00

Cancer Ingestion Intake (Age 16 - 30) = 1.37E-06 Cancer Dermal Intake (Age 16 - 30) = 1.76E+01

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 1.92E-05 Noncancer Dermal Intake = 2.47E+02

Cancer risk from ingestion = Groundwater concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Groundwater concentration x Cancer Dermal Intake x DAevent x Dermal Cancer Slope Factor

Hazard Index from ingestion = Groundwater concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Groundwater concentration x Noncancer Dermal Intake x DAevent / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

REASONABLE MAXIMUM EXPOSURE - ADULT RESIDENTS - INHALATION OF VOLATILES FROM GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Residents	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 1991	Exposure Concentration (mg/m^3) =
				GW	Chemical concentration in water.	95% UCL or Max	ug/L	USEPA, 2002	
				CF	Conversion Factor	0.001	mg/ug	--	CA x ET x EF x ED
				ET	Exposure Time	24	hours/day	USEPA, 1991	AT x 24 hours/day
				EF	Exposure Frequency	350	days/year	USEPA, 1991	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(1), USEPA, 1989, 2005	CA = CW x CF x VF
				ED2	Exposure Duration (Age 16 - 30)	14	years	(1), USEPA, 1989, 2005	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1997	
				AT-N	Averaging Time (Non-Cancer)	8496	days	USEPA, 1989	
				VF	Volatilization Factor	0.5	L/m3	USEPA, 1989	

Notes:

1 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals. OSWER Directive 9285.7-01B.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 1.37E-04 Noncancer Inhalation Intake = 4.12E-04

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS

CENTRAL TENDENCY EXPOSURE - ADULT RESIDENTS - INHALATION OF VOLATILES FROM GROUNDWATER

NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Air

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Inhalation	Residents	Adult	Site 12	CA	Chemical concentration in air	Calculated	mg/m3	USEPA, 1991	Exposure Concentration (mg/m^3) =
				GW	Chemical concentration in water.	95% UCL or Max	ug/L	USEPA, 2002	
				CF	Conversion Factor	0.001	mg/ug	--	CA x ET x EF x ED
				ET	Exposure Time	24	hours/day	USEPA, 1991	AT x 24 hours/day
				EF	Exposure Frequency	350	days/year	USEPA, 2004	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(1), USEPA, 1993, 2005	CA = CW x CF x VF
				ED2	Exposure Duration (Age 16 - 30)	5	years	(1), USEPA, 1993, 2005	
				AT-C	Averaging Time (Cancer)	25550	days	USEPA, 1997	
				AT-N	Averaging Time (Non-Cancer)	2478	days	USEPA, 1989	
				VF	Volatilization Factor	0.5	L/m3	USEPA, 1989	

Notes:

1 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, residential adults will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Human Health Evaluation Manual, Part B: Development of Risk-based Preliminary Remediation Goals. OSWER Directive 9285.7-01B.

USEPA, 1997: Exposure Factors Handbook. USEPA/600/8-95/002FA.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10.

Unit Intake Calculations

Unit Exposure Concentration = (ET x EF x ED)/(AT x 24 hours/day)

Cancer Inhalation Intake = 2.74E-05 Noncancer Inhalation Intake = 2.82E-04

Cancer risk from ingestion = Air concentration x Cancer Inhalation Intake x Inhalation Cancer Slope Factor

Hazard Index from ingestion = Air concentration x Noncancer Inhalation Intake / Inhalation Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
REASONABLE MAXIMUM EXPOSURE - ADULT RESIDENTS - SEDIMENT
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	100	mg/day	USEPA, 2002b	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CSx IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.5	unitless	(1)	BW x AT
				EF	Exposure Frequency	24	days/year	(2)	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(3), USEPA, 2002b, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(3), USEPA, 2002b, 2005	
				BW	Body Weight	70	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	
Dermal	Residents	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002a	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	24	days/year	(2)	
				ED1	Exposure Duration (Age 6 - 16)	10	years	(3), USEPA, 2002b, 2005	
				ED2	Exposure Duration (Age 16 - 30)	14	years	(3), USEPA, 2002b, 2005	
				BW	Body Weight	70	kg	USEPA, 2002b	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	8,760	days	USEPA, 1989	

Notes:

1 - Professional judgment. Receptor is only at the site part of the day.

2 - Assumes one hour a day for one day a week for 24 weeks during late spring, summer, and early fall.

3 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, adult residents will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 2002a: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2002b: Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-24.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 30) = 1.61E-08 Cancer Dermal Intake (Age 6 - 30) = 1.29E-07

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 6.71E-09 Cancer Dermal Intake (Age 6 - 16) = 5.35E-08

Cancer Ingestion Intake (Age 16 - 30) = 9.39E-09 Cancer Dermal Intake (Age 16 - 30) = 7.50E-08

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 4.70E-08 Noncancer Dermal Intake = 3.75E-07

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

VALUES USED FOR DAILY INTAKE CALCULATIONS
CENTRAL TENDENCY EXPOSURES - ADULT RESIDENTS - SEDIMENT
NAS BRUNSWICK, BRUNSWICK, MAINE

Scenario Timeframe: Future
Medium: Sediment
Exposure Medium: Sediment

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference	Intake Equation/ Model Name
Ingestion	Residents	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Intake (mg/kg/day) =
				IR-S	Ingestion Rate	50	mg/day	USEPA, 1993	
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	CS x IRS x CF3 x FI x EF x ED
				FI	Fraction Ingested	0.5	unitless	(1)	BW x AT
				EF	Exposure Frequency	24	days/year	(2)	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(3), USEPA, 1993, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(3), USEPA, 1993, 2005	
				BW	Body Weight	70	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	
Dermal	Residents	Adult	Site 12	CS	Chemical concentration in sediment	Max or 95% UCL	mg/kg	USEPA, 2002	Dermally Absorbed Dose (mg/kg/day) =
				CF3	Conversion Factor 3	1.0E-06	kg/mg	--	
				SA	Skin Surface Available for Contact	5,700	cm2	USEPA, 2004	CS x CF3 x SA x SSAF x DABS x EV x EF x ED
				SSAF	Soil to Skin Adherence Factor	0.07	mg/cm2/event	USEPA, 2004	BW x AT
				DABS	Absorption Factor	Chemical Specific	unitless	USEPA, 2004	
				EV	Events Frequency	1	events/day	USEPA, 2004	
				EF	Exposure Frequency	24	days/year	(2)	
				ED1	Exposure Duration (Age 6 - 16)	2	years	(3), USEPA, 1993, 2005	
				ED2	Exposure Duration (Age 16 - 30)	5	years	(3), USEPA, 1993, 2005	
				BW	Body Weight	70	kg	USEPA, 1993	
				AT-C	Averaging Time (Cancer)	25,550	days	USEPA, 1989	
				AT-N	Averaging Time (Non-Cancer)	2,555	days	USEPA, 1989	

Notes:

1 - Professional judgment. Receptor is only at the site part of the day.

2 - Assumes one day every other week during the late spring, summer, and early fall months (50 perecnt of RME).

3 - Adults will be evaluated as one age group (7 - 30 years) for non-mutagenic chemicals. For chemicals that act via the mutagenic mode of action, adult residents will be evaluated as two age groups, 7 - 16 years and 16 - 30 years in accordance with USEPA's Supplemental Guidance of Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA, 2005).

Sources:

USEPA, 1989: Risk Assessment Guidance for Superfund. Vol 1: Human Health Evaluation Manual, Part A. EPA/540/1-86/060.

USEPA, 1991: Risk Assessment Guidance for Superfund - Supplemental Guidance- Standard Default Exposure Factors Interim Final.

USEPA, 1993: Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure.

USEPA, 2002: Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. OSWER 9285.6-10, December.

USEPA, 2004: Risk Assessment Guidance for Superfund (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540/R/99/005.

Unit Intake Calculations

Incidental Ingestion Intake = (IR-S x CF3 x FI x EF x ED)/(BW x AT)

Dermal Intake = (CF3 x SA x SSAF x EF x ED)/(BW x AT)

Non-Mutagenic Chemicals

Cancer Ingestion Intake = 2.35E-09 Cancer Dermal Intake = 3.75E-08

Mutagenic Chemicals

Cancer Ingestion Intake (Age 6 - 16) = 6.71E-10 Cancer Dermal Intake (Age 6 - 16) = 1.07E-08

Cancer Ingestion Intake (Age 16 - 30) = 1.68E-09 Cancer Dermal Intake (Age 16 - 30) = 2.68E-08

Noncarcinogenic Chemicals

Noncancer Ingestion Intake = 2.35E-08 Noncancer Dermal Intake = 3.75E-07

Cancer risk from ingestion = Sediment concentration x Cancer Ingestion Intake x Oral Cancer Slope Factor

Cancer risk from dermal contact = Sediment concentration x Cancer Dermal Intake x Absorption Factor x Dermal Cancer Slope Factor

Hazard Index from ingestion = Sediment concentration x Noncancer Ingestion Intake / Oral Reference Dose

Hazard Index from dermal contact = Sediment concentration x Noncancer Dermal Intake x Absorption Factor / Dermal Reference Dose

APPENDIX E

ECOLOGICAL HEALTH RISK ASSESSMENT

ECOLOGICAL RISK ASSESSMENT METHODOLOGY

The goal of the ecological risk assessment (ERA) for Site 12 EOD Area will be to evaluate the potential for adverse ecological impacts of site-related contamination and to determine the need for further investigation and/or remedial action at the site. The ERA will contain information to enable scientists and managers to conclude either that ecological risks at the site are most likely negligible or that further information is necessary to evaluate potential ecological risks at the site.

The ERA will be conducted in accordance with the following guidance documents:

- Navy Policy for Conducting Ecological Risk Assessment, Navy, 1999.
- Navy Guidance for Conducting Ecological Risk Assessments (http://web.ead.anl.gov/ecorisk/index.cfm)
- Final Guidelines for Ecological Risk Assessment, United States Environmental Protection Agency (USEPA), 1998.
- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, USEPA, 1997.

The ERA will consist of Steps 1, 2, and 3a of the eight step ERA process. The first two screening steps comprise the screening-level ecological risk assessment (SERA), and correspond with Tier 1 of the Navy Policy (Navy, 1999), where conservative exposure estimates are compared to screening-level and threshold toxicity values. Step 3a is the first step of a baseline ecological risk assessment (BERA) and consists of refining the Tier 1 assumptions following Steps 1 and 2 to further focus the ERA process on the chemicals of greatest concern at a site. Step 3a corresponds with the first part of Tier 2 of the Navy Policy (Navy, 1999). The remaining steps of the ERA process require revision to the Work Plan and Field Sampling Plan prior to initiation, and will not be included in the ERA.

1.0 Tier 1, Step 1: Screening-Level Problem Formulation and Ecological Effects Evaluation

Problem formulation is the first step of an ERA. The problem formulation process enables the risk assessor to identify the ecological resources to be protected (known as assessment endpoints); the measurements that will be used to evaluate risks to those resources (known as measurement endpoints); and the chemicals, geographic areas, and environmental media relevant to the risk assessment.

1.1 Environmental Setting

The site is an open field used for disposal of ordnance/explosives and includes a three-sided, earthen berm area. Site 12 EOD Area encompasses an area of approximately 113 acres. A dirt road surrounds most of the site. A pond is located on the eastern edge of the site. Surface water at the site flows to the west toward Mere Brook and some flows east toward the pond. Potential ecological receptors at the site likely include plants, soil invertebrates, sediment invertebrates, aquatic organisms, and small mammals and birds.

1.2 Potential Sources of Contamination

The site is a former disposal area for ordnance and explosives used from 1981 to 2004. Contaminants such as volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), explosives, petroleum hydrocarbons, and metals may have impacted soil, and sediment.

1.3 Potential Exposure Pathways

Terrestrial ecological receptors, such as plants, soil invertebrates, mammals, and birds, can be exposed to contaminated surface soil through direct contact as they search for food and burrow into the soil. Benthic invertebrates and other aquatic organisms can be exposed to chemicals in sediment. Mammals and birds can also ingest contaminated surface soil, sediment, and food items in which contaminants have accumulated.

1.4 Assessment and Measurement Endpoints

Assessment endpoints are explicit expressions of the environmental value that is to be protected (USEPA, 1997). The selection of these endpoints is based on the habitats present, the migration pathways of chemicals, and the routes that chemicals may take to enter receptors. Measurement endpoints are estimates of biological impacts (e.g., mortality, growth, reproduction) used to evaluate the assessment endpoints. The assessment and measurement endpoints that will be used to evaluate site data are presented in Table 1. The potential receptors at the site for soil exposure include terrestrial plants, soil invertebrates, and herbivorous and insectivorous mammals and birds.

For vertebrate receptors, selection of a particular species is required so that intake through eating can be estimated. The following surrogate species will be used for the food chain modeling:

- Herbivorous mammal: meadow vole

- Herbivorous bird: bobwhite quail
- Insectivorous mammal: short-tailed shrew
- Insectivorous bird: American robin
- Piscivorous mammal: Mink
- Piscivorous bird: Belted Kingfisher

USEPA guidance (USEPA, 1997) states that "it is not practical or possible to directly evaluate risks to all of the individual components of the ecosystem at a site. Instead, assessment endpoints focus the risk assessment on particular components of the ecosystem that could be adversely affected by chemicals from the site." Therefore, this ERA focuses on the endpoints tending to yield the highest risks, which should account for endpoints that have lower risks.

Large carnivorous birds and mammals were not selected as assessment endpoints because their home range (hundreds of acres) is larger than the site (approximately 113 acres). When the sizes of the sites are compared to the home ranges of top carnivores, such as the red-tailed hawk (approximately 1,700 acres) and the red fox (approximately 1,800 acres), carnivores would receive only a very small portion of their diet from site. Therefore, risks would be greater to small mammals and birds that obtain all or most of their food from the site. Although some reptiles (e.g., snakes) and amphibians may be present at the site, they were not selected as assessment endpoints because of the lack of toxicity information and the lack of methods to evaluate their exposure to chemicals.

1.5 Conceptual Site Model

A conceptual site model (CSM) in ERA problem formulation is a written description of predicted relationships between ecological entities and the stressors to which they may be exposed (USEPA, 1998). The CSM consists of two primary components: predicted relationships among stressor, exposure, and assessment endpoint response, and a diagram that illustrates the relationships (USEPA, 1998). At the site, the sources of the chemicals include VOCs, SVOCs, explosives, petroleum hydrocarbons, and metals associated with the former disposal area. The exposure media includes surface soil and sediment. Surface water runoff carrying contaminated soil from the site or off-site areas may have led to contamination of sediment at the site. Because the site consists of different habitats such as vegetated areas and nearby pond, a variety of terrestrial and aquatic receptors may be present at the site. For this ERA, surface soil will be defined as 0 to 1 foot and 0 to 0.5 feet for sediment.

2.0 Tier 1, Step 2: Screening-Level Exposure Estimate and Risk Quotients

2.1 Ecological Effects Evaluation

The preliminary ecological effects evaluation is an investigation of the relationship between exposure to a chemical and the potential for adverse effects resulting from exposure. In this step, conservative screening levels for evaluating the toxicity to ecological receptors from the detected levels of chemicals at the sites are compiled.

Terrestrial plants and soil invertebrates

Risks to terrestrial plants and soil invertebrates resulting from direct exposure to chemicals will be evaluated by comparing the chemical concentrations in the surface soil to screening levels. In order of preference, the first source selected for the screening levels is the USEPA Ecological Soil Screening Levels (Eco SSLs) (http://www.epa.gov/ecotox/ecossl/). If an Eco SSL is not available for a particular chemical or receptor, then Canadian Soil Quality Guidelines (CCME) (http://ceqg-rcqe.ccme.ca/), followed by Oak Ridge National Laboratory (ORNL) Toxicological Benchmarks for invertebrates (Efroymson et al., 1997a) and plants (Efroymson et al., 1997b), Ecotoxicology of Explosives (Sunahara et al., 2009), and ECORISK Database (Release 3.0) (LANL, 2011) will be used. Eco SSLs will be used first because they are the most current soil screening levels.

Sediment invertebrates

Risks to sediment invertebrates resulting from direct exposure to chemicals will be evaluated by comparing the chemical concentrations in the sediment to screening levels. The screening levels consist of threshold effects concentrations (MacDonald, et al., 2000), followed by lowest effects levels (Persaud, et al., 1993), USEPA ecotox thresholds, sediment quality benchmarks (USEPA, 1996), National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables for freshwater sediment and marine sediment with values for freshwater sediment selected first (Buchman, 2008), secondary chronic values (Jones, et al., 1997), Region 5 ecological screening values for sediment (USEPA, 2003), and ECORISK Database (Release 3.0) (LANL, 2011).

Mammals and birds

Potential risks to mammals and birds resulting from exposure to chemicals in the surface soil will be evaluated by comparing chemical concentrations to ecological screening levels. Screening levels for piscivorous mammals and birds exposed to chemicals in sediment are not available. If a chemical

concentration exceeds its screening level or a screening level is not available, the chemical will be evaluated using food chain models for risks to mammals and birds.

Risks to mammals and birds from exposures to chemicals in the surface soil and sediment will be determined by estimating the Chronic Daily Intake (CDI) and comparing the CDI to toxicity reference values (TRVs) representing acceptable daily doses in mg/kg-day. The TRVs, including no observed adverse effects levels (NOAELs), and lowest observed adverse effect levels (LOAELs) will be obtained from wildlife studies presented in the USEPA Eco SSLs (http://www.epa.gov/ecotox/ecossl/) and ORNL Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al., 1996) and will be supplemented with other toxicity information when necessary. If a subchronic study is used to develop the TRV, the final value will be multiplied by a factor of 0.1 to account for uncertainty between subchronic and chronic effects. Also, the LOAEL will be multiplied by a factor of 0.1 to estimate a NOAEL TRV if only a LOAEL study is available. The chemical-specific Eco SSL documents provide both NOAELs and LOAELS for various studies, but TRVs are generally calculated only for NOAELs. The geometric mean of the chemical-specific growth and reproduction LOAELs from the chemical-specific Eco SSL documents will be used as the LOAEL TRVs for several metals. This approach will be used because the survival LOAELs tend to be greater than growth or reproductive LOAELs and the selected LOAELs are generally much lower than many NOAELs for growth, reproduction, and survival.

2.2 Exposure Characterization

Terrestrial soil invertebrates and plants are exposed to chemicals in the surface soil through direct contact and/or ingestion. Sediment invertebrates are exposed to chemicals in sediment through direct contact and/or ingestion. Maximum chemical concentrations in soil and sediment will be used in the screening step to select chemicals of potential concern (COPCs).

Doses in mg/kg-day will be estimated for terrestrial wildlife (mammals and birds) using exposure equations. The following equation will be used to calculate the exposure dose for terrestrial wildlife from exposure to chemicals in soil, sediment and associated food items (e.g., plants and invertebrates):

$$CDI = \frac{\left[\left(C_f * I_f\right) + \left(C_s * I_s\right)\right] * H}{BW}$$

Where:

CDI	=	chronic daily intake (mg/kg-day)
C_f	=	chemical concentration in food (mg/kg) (see discussion below)
C_s	=	chemical concentration in surface soil or sediment(mg/kg)

I_f	=	food ingestion rate (kg/day)
I_s	=	incidental surface soil/sediment ingestion rate (kg/day)
H	=	portion of food intake from the contaminated area (unitless)
BW	=	body weight (kg)

The exposure assumptions (i.e., ingestion rate, body weight) will be obtained primarily from the Wildlife Exposure Factors Handbook (USEPA, 1993) with other sources used as necessary. Food ingestion rates will be presented on a dry weight basis and chemical concentrations in the food items will be estimated in dry weight concentrations. This will be done to be consistent with chemical concentrations in soil, which are reported on a dry weight basis. The exposure assumptions are presented in Table 2.

Chemical concentrations in food items for soil insectivorous and herbivorous receptors will be calculated using soil-to-invertebrate or soil-to-plant bioaccumulation factors (BAFs) or regression equations. The following equation will be used to calculate chemical concentrations in plants or invertebrates when BAFs are used:

$$C_f = C_s * BAF$$

Where:

C_f = Chemical concentration in food (mg/kg)
C_s = Chemical concentration in surface soil (mg/kg)
BAF = Biota-soil bioaccumulation factor (unitless) (soil to plant or soil to earthworm)

The following sources of plants/earthworm BAFs will be used to calculate the chemical concentrations in plants and earthworms:

- Plant and invertebrate BAFs: Guidance for Developing Ecological Soil Screening Level (USEPA, 2007).
- Plant BAFs: ORNL Risk Assessment Information System (http://rais.ornl.gov/cgi-bin/tools/TOX_search?select=chem_spef) (ORNL, 2012).
- BAFs for Explosives: Los Alamos National Laboratory (LANL) ECORISK Database (LANL, 2011)

Chemical concentrations in food items for piscivorous receptors will be calculated using sediment-to-fish biota-sediment bioaccumulation factors (BSAFs) and sediment-to-invertebrate BSAFs. Contaminant concentrations in food items for piscivorous birds will be calculated as follows:

$$\text{Cf (for metals)} = \text{Csd} * \text{BSAF}$$

Where:

Cf = Contaminant concentration in food (mg/kg)
Csd = Contaminant concentration in sediment (mg/kg)
BSAF = Biota-sediment bioaccumulation factor (unitless)

$$\text{Cf (for organics)} = \text{Csd} * \left(\text{BSAF} * \frac{\%\text{L}}{\%\text{TOC}} \right)$$

Where:
Cf = Contaminant concentration in food (mg/kg)
Csd = Contaminant concentration in sediment (mg/kg)
BSAF = Biota-sediment bioaccumulation factor (for organics) (unitless)
%L = Percent lipids [14.4% (dry weight)]
%TOC = Percent total organic carbon (will be determined from site data)

The following sources of BSAFs will be used to calculate the chemical concentrations in sediment invertebrates:

- The Incidence and Severity of Sediment Contamination in Surface Waters of the United States, Volume 1: National Sediment Quality Survey: Second Edition (USEPA, 2004).

- Biota Sediment Accumulation Factors for Invertebrates: Review and recommendations for the Oak Ridge Reservation (ORNL, 1998).

- BAFs for Explosives: LANL ECORISK Database (LANL, 2011)

A default value of 1.0 will be used for the BAF and BSAF when chemical-specific data are not available.

The food chain model scenarios will be calculated using various exposure assumptions to present a range of potential risks. For selection of chemicals as COPCs, the following set of conservative exposure assumptions will be used:

- Maximum soil concentrations

- Conservative receptor body weight and ingestion rates
- Receptors spend 100 percent of their time at the Site

2.3 Risk Characterization

An Ecological Effects Quotient (EEQ) approach will be used to characterize the risk to ecological receptors. This approach characterizes the potential effects by comparing exposure concentrations with the effects data. When EEQs exceed 1.0, it is an indication that ecological receptors are potentially at risk, although additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk, especially because most benchmarks are developed using conservative exposure assumptions and/or studies. An EEQ should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an EPC exceeds or is less than a benchmark.

The EEQs for surface soil receptors will be calculated as follows:

$$EEQ = \frac{Css}{SSSL}$$

where:

EEQ	=	Ecological Effects Quotient (unitless)
Css	=	Chemical concentration in surface soil (µg/kg or mg/kg)
SSSL	=	Surface soil screening level (µg/kg or mg/kg)

The EEQs for sediment invertebrates will be calculated as follows:

$$EEQ = \frac{Csd}{SdSL}$$

where:

EEQ	=	Ecological Effects Quotient (unitless)
Csd	=	Chemical concentration in sediment (µg/kg or mg/kg)
SdSL	=	Sediment screening level (µg/kg or mg/kg)

The EEQs for mammals and birds will be calculated as follows:

$$EEQ = \frac{CDI}{TRV}$$

where:

EEQ	=	Ecological effects quotient (unitless)
CDI	=	Chronic daily intake dose (mg/kg-day)
TRV	=	Toxicity reference value (NOAEL or LOAEL) (mg/kg-day)

2.4 Selection of Chemicals of Potential Concern

The final part of the screening evaluation includes the initial selection of ecological COPCs. Chemicals that are not retained as COPCs are assumed to only cause negligible risk to ecological receptors and will not be evaluated further in the ERA. Chemicals that are initially selected as COPCs will be further evaluated in Step 3a to determine if they will be retained as final COPCs. The initial ecological COPCs will be selected by the following procedures:

- For plants, soil invertebrates, and sediment invertebrates, chemicals with EEQs greater than 1.0 (using screening values) will be selected as COPCs because they have a potential to cause risk to ecological receptors.

- For birds and mammals, chemicals with EEQs greater than 1.0 based on the food chain model using NOAELs will be selected as COPCs because they have the potential to cause risks to higher trophic level mammals and birds.

- Chemicals without screening values will be selected as COPCs, but only evaluated qualitatively.

- Calcium, magnesium, potassium, and sodium will not be selected as COPCs, because they are essential nutrients that can be tolerated by living systems even at high concentrations. No evidence indicates that these chemicals are related to site operations, and they are not considered hazardous chemicals.

3.0 Tier 2, Step 3a: COPC Refinement

The purposes of Step 3a are to re-evaluate the COPCs that are retained from Tier 1 for further evaluation in a Tier 2 BERA and to identify and eliminate from further consideration those chemicals that are only selected as COPCs because of the use of very conservative exposure scenarios. Using less conservative (but more realistic) assumptions, the Tier 1 risk estimates will be recalculated and the new estimates will be used to refine the list of COPCs identified by the Tier 1 screening risk assessment in order to focus any additional efforts on chemicals that are of primary ecological concern.

For chemicals that are evaluated further in Step 3a, the following factors will be evaluated, as appropriate, to determine if the risks are great enough to warrant additional evaluations. Note that all of these factors might not be applicable for each chemical and/or receptor group.

- Magnitude of criterion exceedance: Although the magnitude of the risks may not relate directly to the magnitude of a criterion exceedance, the magnitude of the criterion exceedance may be one item used in a lines-of-evidence approach to determine the need for further site evaluation. The greater the criterion exceedance, the greater the probability and concern that an unacceptable risk exists.

- Frequency of chemical detection and spatial distribution: A chemical detected at a low frequency typically is of less concern than a chemical detected at higher frequency if toxicity values, concentrations, and spatial areas represented by the data are similar. All else being equal, chemicals detected frequently will be given greater consideration than those detected relatively infrequently. In addition, the spatial distribution of a chemical may be evaluated to determine the area that a sample, or samples, represents.

- Background: Concentrations of chemicals in surface soil and sediment will be compared to background concentration data if available. If the concentration of a detected chemical is not greater than the background concentration, the chemical will be considered as not site-related and eliminated as a COPC.

- Contaminant bioavailability: Many contaminants (especially inorganics) are present in the environment in forms that are typically not bioavailable, and the limited bioavailability will be considered when evaluating the exposures of receptors to site contaminants. Contaminants with generally less bioavailability will be considered to be less toxic than the more bioavailable contaminants, all other factors being equal.

- Additional Benchmarks: Alternative benchmarks will be used to further evaluate risks to specific groups of ecological receptors (e.g., plants and invertebrates).

- Food Chain Modeling: Exposure via the food chain is a major pathway of concern for chemicals known to significantly bioaccumulate and/or biomagnify. Thus, potential risk to upper level receptors is evaluated using food chain models. The Tier 1 exposure doses calculated for terrestrial wildlife will be re-calculated using the following Tier 2, Step 3A exposure assumptions and chemical concentrations:
  - Weighted soil concentrations (see below)
  - Average receptor body weights and ingestion rates

For the Step 3a food chain model, a weighted average concentration will be used as the exposure point concentration because the data consist of a combination of incremental sampling method (ISM) and grab samples, and the site is divided into a few decision units which are different sizes (see Figure 17-3). However, the wildlife receptors are expected to feed equally across the sits so this approach avoids biasing the results toward areas that have greater sample densities. The weighted average calculation will be conducted, as follows:

- In Decision Units (DUs) 2, 3, and 4, the ISM samples within each DU will be averaged together to obtain one concentration for each chemical that represents each the three DUs.
- The area of each DU will then be determined.
- The chemical concentration of each DU will be multiplied by the area of that DU to get a weighted chemical concentration for each DU.
- The weighted chemical concentrations for each of the DU will be averaged together, and then divided by the total area of the three EUs to obtain the overall weighted chemical concentrations for the site.

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TABLE 1

ASSESSMENT ENDPOINTS AND MEASUREMENT ENDPOINTS
ECOLOGICAL RISK ASSESSMENT METHODOLOGY
NAS BRUNSWICK
BRUNWICK, MAINE

Assessment Endpoint	Measurement Endpoint
Adverse effects on the survival, reproduction, and/or growth of soil invertebrates	• Survival, growth, and/or reproduction of soil invertebrates will be evaluated by comparing the measured concentrations of chemicals in the surface soil to invertebrate soil screening levels.
Adverse effects on the survival, reproduction, and/or growth of sediment invertebrates	• Survival, growth, and/or reproduction of sediment invertebrates will be evaluated by comparing the measured concentrations of chemicals in the sediment to sediment screening levels.
Adverse effects on the survival, reproduction, and/or growth of terrestrial plants	• Survival, growth, and/or reproduction of terrestrial plants will be evaluated by comparing the measured concentrations of chemicals in the surface soil to plant soil screening levels.
Adverse effects on the survival, reproduction, and/or increase in development effects of insectivorous birds	• Survival, reproduction, and/or increase in development effects of birds will be evaluated by comparing the estimated ingested dose of contaminants in the surface soil and earthworms to No Observed Adverse Effects Levels (NOAELs) and Lowest Observed Adverse Effects Levels (LOAELs) for surrogate wildlife species.
Adverse effects on the survival, reproduction, and/or increase in development effects of insectivorous mammals	• Survival, reproduction, and/or increase in development effects of mammals will be evaluated by comparing the estimated ingested dose of contaminants in the surface soil and earthworms to NOAELs and LOAELs for surrogate wildlife species.
Adverse effects on the survival, reproduction, and/or increase in development effects of herbivorous birds	• Survival, reproduction, and/or increase in development effects of birds will be evaluated by comparing the estimated ingested dose of contaminants in the surface soil and plants to NOAELs and LOAELs for surrogate wildlife species.
Adverse effects on the survival, reproduction, and/or increase in development effects of herbivorous mammals	• Survival, reproduction, and/or increase in development effects of mammals will be evaluated by comparing the estimated ingested dose of contaminants in the surface soil and plants to NOAELs and LOAELs for surrogate wildlife species.
Adverse effects on the survival, reproduction, and/or increase in development effects of piscivorous mammals	• Survival, reproduction, and/or increase in development effects of mammals will be evaluated by comparing the estimated ingested dose of contaminants in the sediment and aquatic organisms to NOAELs and LOAELs for surrogate wildlife species.
Adverse effects on the survival, reproduction, and/or increase in development effects of piscivorous birds	• Survival, reproduction, and/or increase in development effects of birds will be evaluated by comparing the estimated ingested dose of contaminants in the sediment and aquatic organisms to NOAELs and LOAELs for surrogate wildlife species.

TABLE 2

EXPOSURE PARAMETERS FOR THE TERRESTRIAL WILDLIFE MODEL
ECOLOGICAL RISK ASSESSMENT METHODOLOGY
NAS BRUNSWICK
BRUNSWICK, MAINE

	Conservative Inputs		Average Inputs	
Species/Exposure Inputs	**Values**	**Units**	**Values**	**Units**
Meadow Vole				
Body Weight = BW	1.700E-02	kg	3.580E-02	kg
Food Ingestion Rate = If	1.878E-03	kg/day	1.744E-03	kg/day
Water Ingestion Rate = Iw	7.513E-03	L/day	6.261E-03	L/day
Soil Ingestion Rate = Is	6.010E-05	kg/day	2.093E-05	kg/day
Home Range = HR	Assume 100% on site		6.590E-02	acres
Bobwhite Quail				
Body Weight = BW	1.540E-01	kg	1.751E-01	kg
Food Ingestion Rate = If	1.628E-02	kg/day	1.361E-02	kg/day
Water Ingestion Rate = Iw	2.276E-02	L/day	1.926E-02	L/day
Soil Ingestion Rate = Is	2.263E-03	kg/day	8.302E-04	kg/day
Home Range = HR	Assume 100% on site		1.880E+01	acres
Short-Tailed Shrew				
Body Weight = BW	1.500E-02	kg	1.610E-02	kg
Food Ingestion Rate = If	1.600E-03	kg/day	1.433E-03	kg/day
Water Ingestion Rate = Iw	4.280E-03	L/day	3.600E-03	L/day
Soil Ingestion Rate - Is	4.801E-05	kg/day	1.289E-05	kg/day
Home Range = HR	Assume 100% on site		9.699E-01	acres
American Robin				
Body Weight = BW	7.73E-02	kg	8.04E-02	kg
Food Ingestion Rate = If	1.25E-02	kg/day	1.19E-02	kg/day
Water Ingestion Rate = Iw	1.21E-02	L/day	1.13E-02	L/day
Soil Ingestion Rate - Is	2.05E-03	kg/day	7.60E-04	kg/day
Home Range = HR	Assume 100% on site		6.10E-01	acres
Belted Kingfisher				
Body Weight = BW	1.360E-01	kg	1.473E-01	kg
Food Ingestion Rate = If	1.975E-02	kg/day	1.842E-02	kg/day
Water Ingestion Rate = Iw	1.738E-01	L/day	1.621E-02	L/day
Sediment Ingestion Rate = Is	6.518E-04	kg/day	6.079E-04	kg/day
Home Range = HR	Assume 100% on site		1.160E+00	km-radius
Mink				
Body Weight = BW	5.500E-01	kg	1.103E+00	kg
Food Ingestion Rate = If	6.067E-02	kg/day	4.504E-02	kg/day
Water Ingestion Rate = Iw	1.213E-01	L/day	7.308E-02	L/day
Sediment Ingestion Rate = Is	5.703E-03	kg/day	4.234E-03	kg/day
Home Range = HR	Assume 100% on site		3.400E+01	acres

Notes:

The soil/sediment ingestion rates were calculated by multiplying the food ingestion rates by the following incidental soil/sediment ingestion rates:

	Conservative	Average	Source
Meadow Vole	3.2%	1.2%	1
Bobwhite quail	13.9%	6.1%	1, 2
Short-tailed Shrew	3%	0.90%	1
American Robin	16.40%	6.40%	1, 3
Kingfisher	3.3%	3.3%	4, 5
Mink	9.4%	9.4%	4, 6

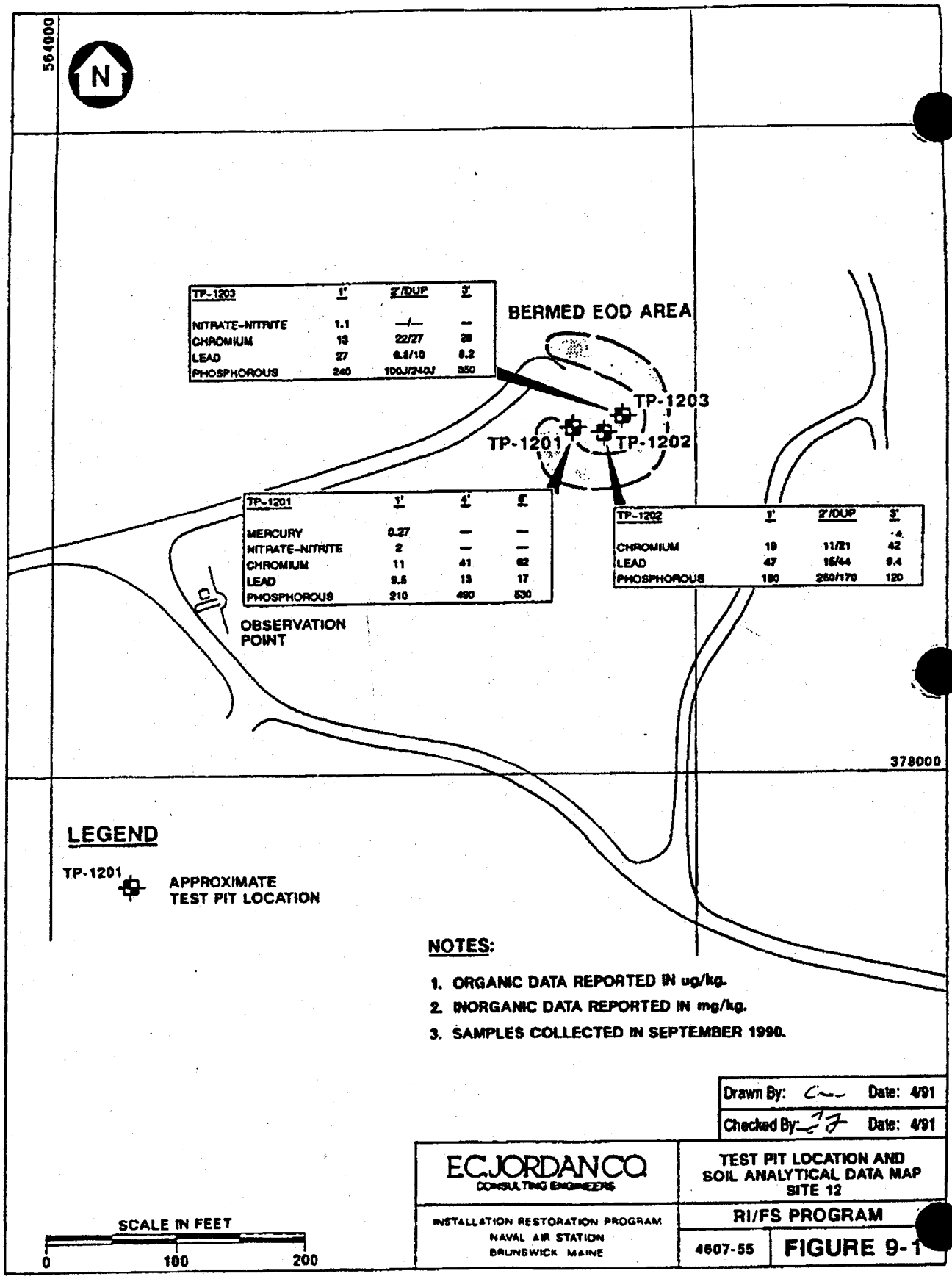
1 - U.S. EPA (U.S. Environmental Protection Agency), 2007. Ecological Soil Screening Level Guidance, Office of Emergency and Remedial Response. February.
2 - Based on the mourning dove.
3 - Based on the American woodcock.
4 - Beyer, N., E. Connor, and S. Gerould. 1994. Estimates of Soil Ingestion by Wildlife. Journal of Wildlife Management 58(2) pp. 375-382.
5- Based on the mallard duck
6 - Based on the raccoon

APPENDIX F

HISTORICAL INFORMATION

MAPS

Click Here to Return to Main Index



TP-1203	1'	2'/DUP	3'
NITRATE-NITRITE	1.1	—/—	—
CHROMIUM	13	22/27	28
LEAD	27	6.8/10	8.2
PHOSPHOROUS	240	100J/240J	350

TP-1201	1'	4'	6'
MERCURY	0.27	—	—
NITRATE-NITRITE	2	—	—
CHROMIUM	11	41	62
LEAD	9.5	13	17
PHOSPHOROUS	210	490	530

TP-1202	1'	2'/DUP	3'
CHROMIUM	19	11/21	42
LEAD	47	16/44	9.4
PHOSPHOROUS	180	260/170	120

NOTES:

1. ORGANIC DATA REPORTED IN ug/kg.
2. INORGANIC DATA REPORTED IN mg/kg.
3. SAMPLES COLLECTED IN SEPTEMBER 1990.

Drawn By: Date: 4/91
Checked By: Date: 4/91

E.C.JORDAN CO.
CONSULTING ENGINEERS

TEST PIT LOCATION AND SOIL ANALYTICAL DATA MAP SITE 12

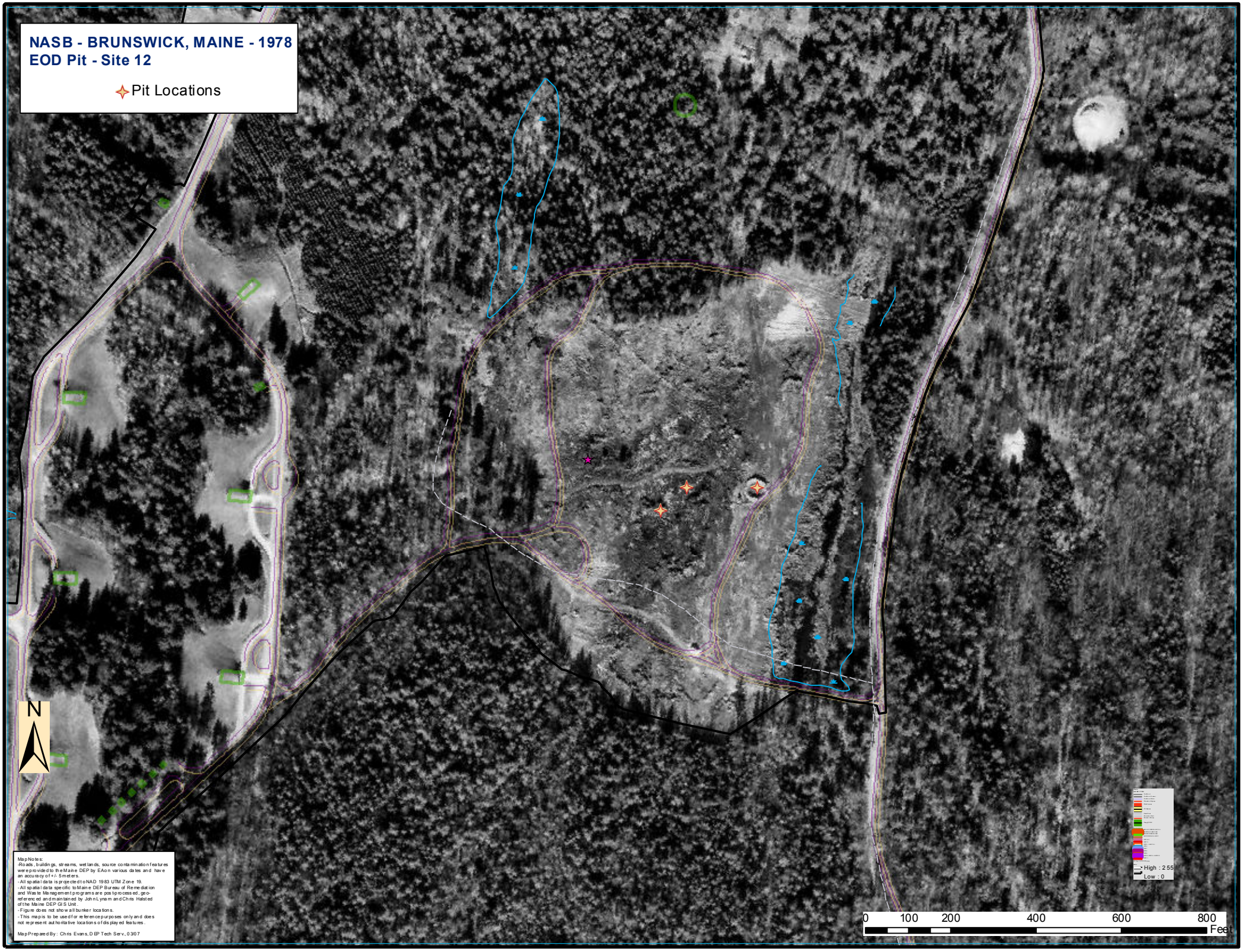
INSTALLATION RESTORATION PROGRAM
NAVAL AIR STATION
BRUNSWICK MAINE

RI/FS PROGRAM

4607-55

FIGURE 9-1

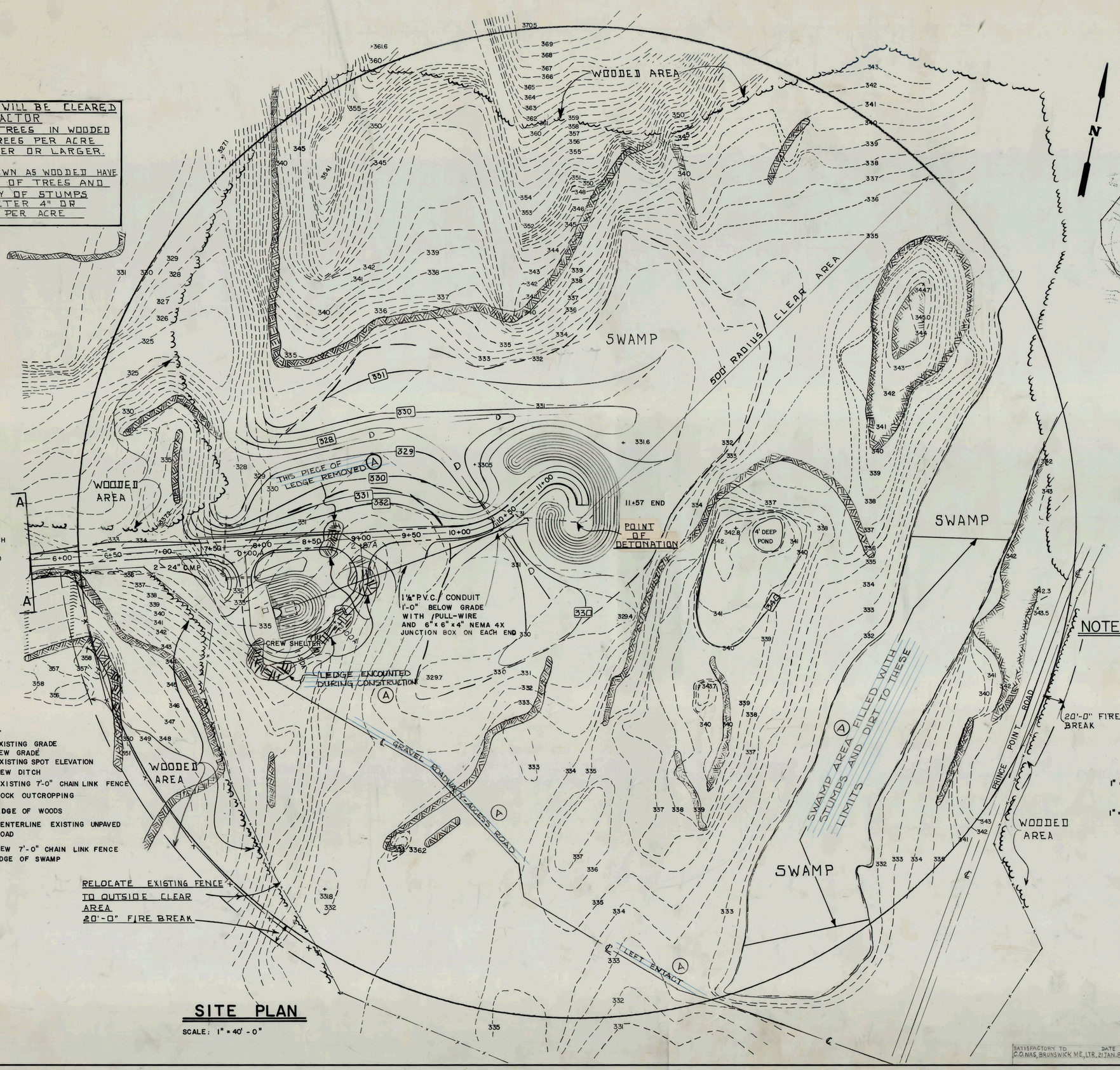
Oct 1958


NASB - BRUNSWICK, MAINE - 1978
EOD Pit - Site 12
Pit Locations
N
Map Notes:
-Roads, buildings, streams, wetlands, source contamination features were provided to the Maine DEP by EA on various dates and have an accuracy of +/- 5 meters.
- All spatial data is projected to NAD 1983 UTM Zone 19.
- All spatial data specific to Maine DEP Bureau of Remediation and Waste Management programs are post-processed, geo-referenced and maintained by John Lynam and Chris Halsted of the Maine DEP GIS Unit.
- Figure does not show all bunker locations.
- This map is to be used for reference purposes only and does not represent authoritative locations of displayed features.
Map Prepared By: Chris Evans, DEP Tech Serv., 03/07
High : 255
Low : 0
0 100 200 400 600 800
Feet

REVISIONS				
LTR.	DESCRIPTION	PREP'D BY	DATE	APPROVED
A	REVISED AS BUILT	D.B.	7-21-81	D.B.

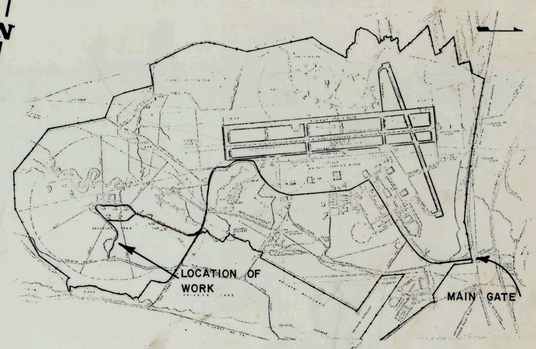
WOODED AREAS WILL BE CLEARED BY THE CONTRACTOR
DENSITY OF TREES IN WOODED AREAS ≤ 517 TREES PER ACRE 4" IN DIAMETER OR LARGER.

AREAS NOT SHOWN AS WOODED HAVE BEEN CLEARED OF TREES AND BRUSH. DENSITY OF STUMPS WITH A DIAMETER 4" OR LARGER ≃ 168 PER ACRE



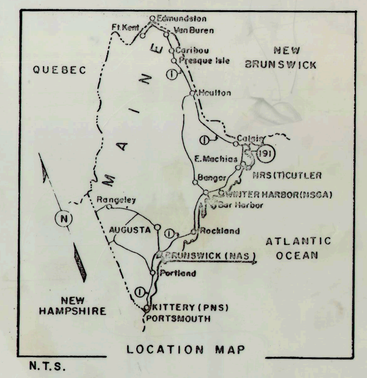
SITE PLAN

SCALE: 1" = 40' - 0"



LOCATION OF WORK

SCALE 1" = 2400'-0"



LOCATION MAP

N.T.S.

NOTE:

1- THE GOVERNMENT WILL CLEAR MARKETABLE TIMBER FROM THE 500' CLEAR AREA
2- THE CONTRACTOR SHALL CLEAR AND GRUB ALL TREES, SHRUBS, AND BRUSH WITHIN THE 500' CLEARED AREA, AND 20' FIREBREAK.
3- TOPSOIL AND SEED ALL AREAS DISTURBED BY CONSTRUCTION EXCEPT ROADS AND 15' RADIUS FROM POINT OF DETONATION.
4- CLEAR 20'-0" FIRE BREAK WHERE FENCE IS WITHIN 5'-0" OF 500' RADIUS.
5- LIMITS OF SWAMP SHOWN ARE THOSE AT TIME OF SURVEY, MARCH, 1979.

LEGEND

- 328 — EXISTING GRADE
- 328 — NEW GRADE
- + 336.2 — EXISTING SPOT ELEVATION
- D — NEW DITCH
- EXISTING 7'-0" CHAIN LINK FENCE
- ROCK OUTCROPPING
- EDGE OF WOODS
- ℄ — CENTERLINE EXISTING UNPAVED ROAD
- X — NEW 7'-0" CHAIN LINK FENCE
- EDGE OF SWAMP

GRAPHIC SCALE:

1" = 40'- 0" : 40' 20' 0 40' 80' 120'

1" = 2400'-0" : 2400' 0 2400' 4800' 7200'

PWD # 2009

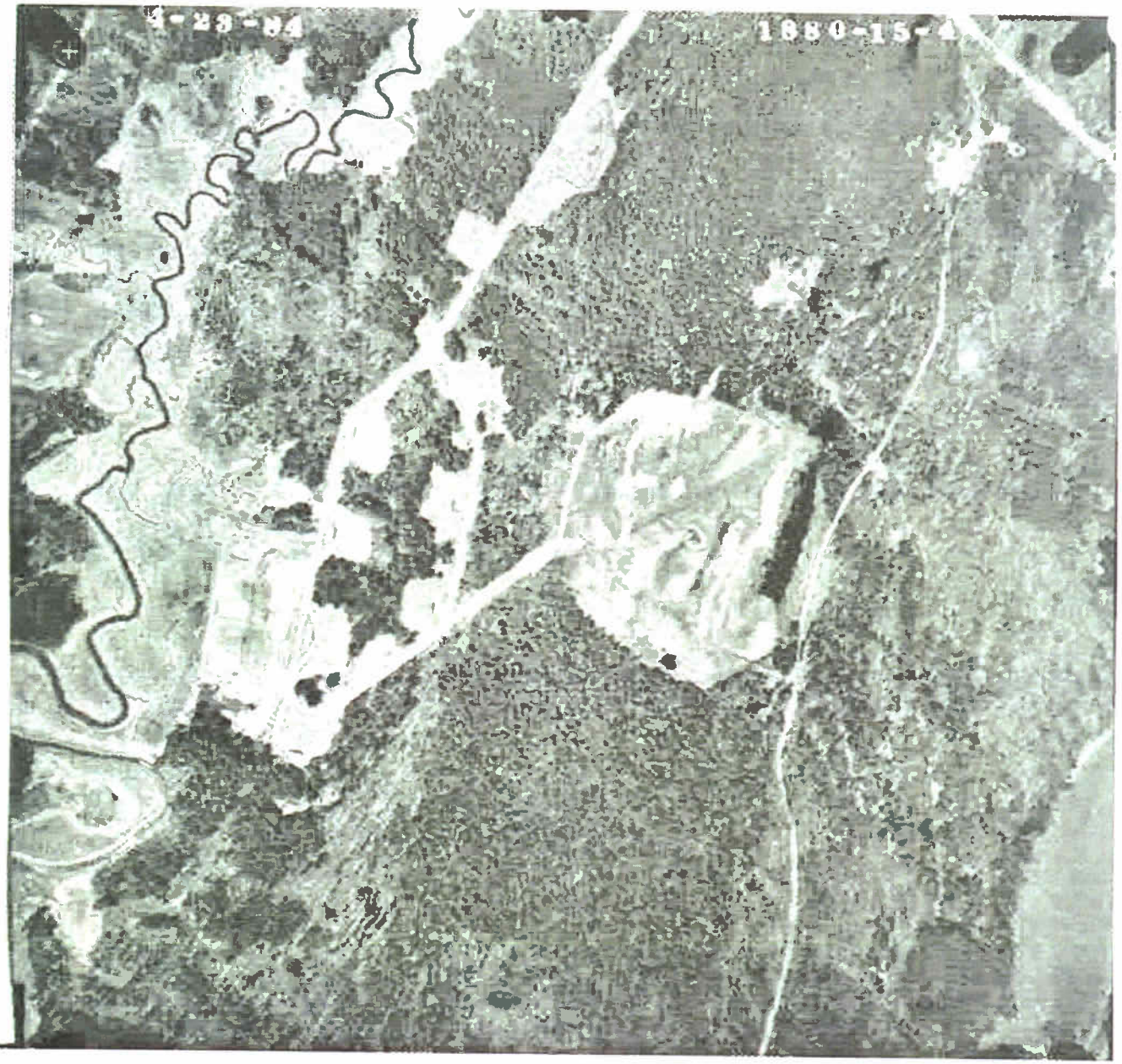
CHECK GRAPHIC SCALES BEFORE USING

NORTHDIV. DWG. NO.	DEPARTMENT OF THE NAVY NAVAL FACILITIES ENGINEERING COMMAND NORTHERN DIVISION
DES. J. ENGELHARDT	NAVAL BASE PHILADELPHIA, PA.
DR. ENGELHARDT CHK.	NAVAL AIR STATION BRUNSWICK, ME
E.I.C. A.I.C. J. ENGELHARDT	ORDNANCE DISPOSAL AREA
HEAD (CIVIL)	SITE PLAN & LOCATION PLAN
HEAD	
HEAD	
DIRECTOR	
APPROVED / DATE	SIZE F · CODE IDENT NO. 80091 · NAVFAC DRAWING NO. 2043085
FOR COMMANDER, NAVFAC	SCALE 1" = 40'-0" · CONSTR. CONTR. NO. N62472-78-C-0262 · SPEC. 04-78-0262 · SHEET 1 OF 4

SATISFACTORY TO C.O. NAS, BRUNSWICK ME., LTR. 21 JAN. 80 — DATE

FILE 1723

NOV 1981



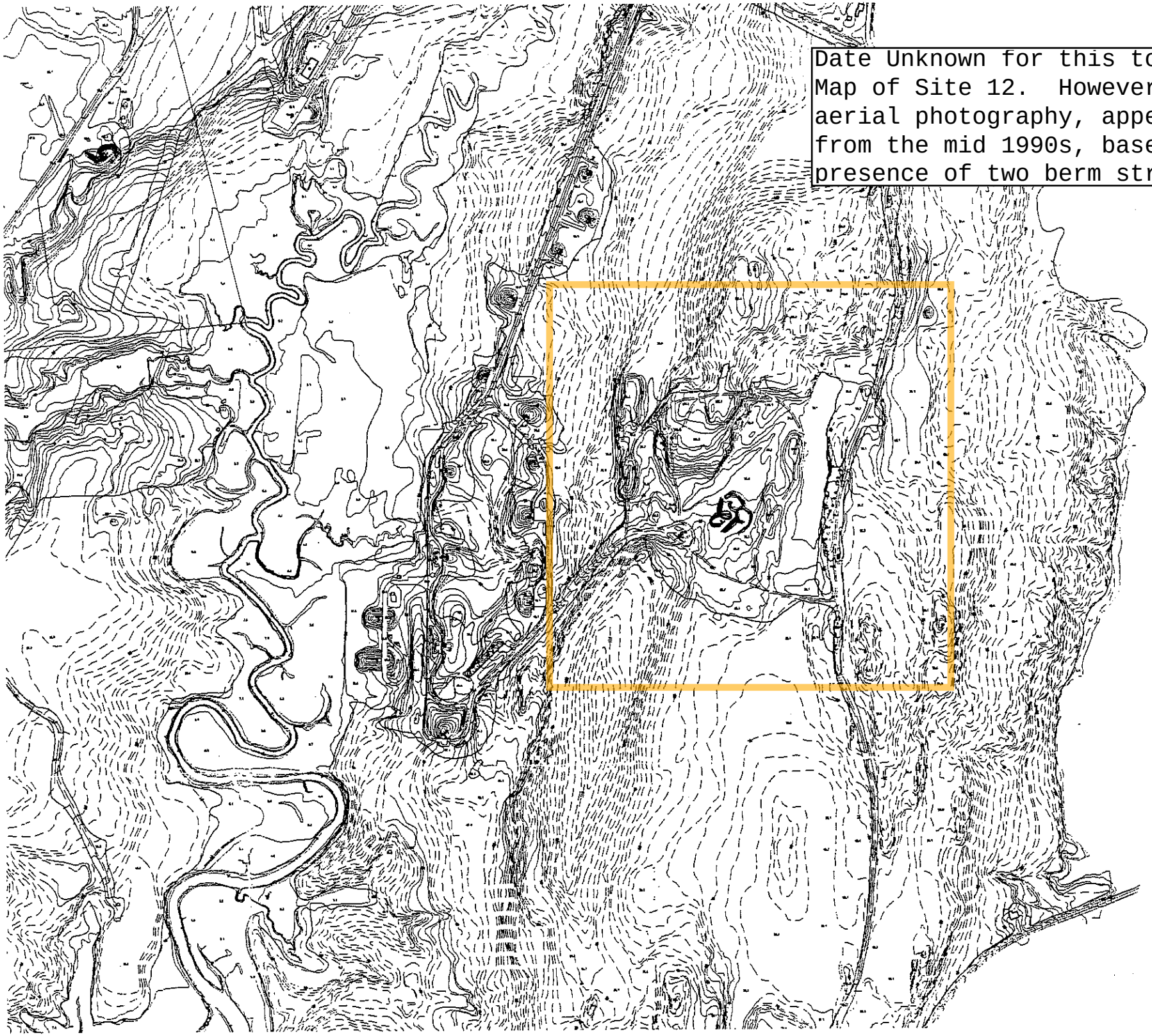
April 1984

April 1989

May 1992

Nov 1993

USGS Earth Resources Observation & Science (EROS) Center
Digital Orthophoto Quadrangle: DI00000000961525-ORRS ISLAND-NE,ME
Publication_Date: 19990318
http://edcsns17.cr.usgs.gov/browse/doq_qq/O/orrs_island_ME/O4306909.NES.961525.jpg
Photo Date: 19960507



Date Unknown for this topographical Map of Site 12. However, based on aerial photography, appears to be from the mid 1990s, based on the presence of two berm structures.

Image © 2007 Maine GeoLibrary
© 2007 Europa Technologies
Google™
Pointer 43°52'14.35" N 69°55'20.10" W elev 78 ft
Streaming 100%
Eye alt 2293 ft

Image © 2007 Maine GeoLibrary
© 2007 Europa Technologies
Google
Pointer 43°52'20.17" N 69°55'14.44" W elev 79 ft
Streaming 100%
Eye alt 592 ft

GEOLOGY

The Field Investigation of Bedrock in the Explosive Ordinance Disposal Range Brunswick Naval Air Station

January 22, 2003

1.0 Background

At the request of the U.S. Environmental Protection Agency (USEPA), Gannet Fleming (GF) performed a field investigation of bedrock outcrops in the Explosive Ordinance Disposal (EOD) range of Brunswick Naval Air Station on December 2, 2002. Gannett Fleming gratefully acknowledges the assistance of Dr. Arthur Hussey, Professor Emeritus, Bowdon College; and that of Tony Williams, Environmental Manager for Brunswick Naval Air Station, in this investigation.

The objective of the field investigation was to observe bedrock structure, composition, morphology, and fracturing in order to guide the proposed geophysical investigation of bedrock near Site 11. Such observations may contribute to our knowledge of the bedrock at Site 11 by providing:

- Characteristic orientations, widths and depths of significant bedrock depressions, necessary to structure the geophysical investigation appropriately.

- Insight into which of 9 proposed lineaments may be physically real, fracture-related bedrock depressions.

- Characteristic morphology and fracturing of bedrock rises, suggesting mechanisms by which groundwater of conduct of overburden layers may interact with bedrock.

The EOD range proved an excellent choice for this investigation since the area has minimal overburden, is largely cleared of woods, and has abundant bedrock outcrops.

This document presents key findings of the 2002 bedrock investigation, and summarizes ramifications for the proposed 2003 geophysical investigation. Further field investigation with Dr. Hussey's assistance is planned for spring 2003, prior to updating the 2003 workplan. A more detailed report covering all non-geophysical field investigations into bedrock will be released in the late spring.

2.0 Regional Bedrock

The Eastern Plume at Naval Air Station, Brunswick resides over the Cape Elizabeth Formation (CE). This formation is characterized as thinly-bedded gray schist, composed primarily of quartz-plagioclase-biotite-muscovite, and characteristically interbedded with thin beds of quartzite schist. It exhibits differential weathering and erosional features which result from rock layering and lithologic variability. Bedding planes and schistosity (a cleavable planar layering in the rock) of the formation characteristically strike to the NNE, and dip steeply to the SE.

3.0 Key Findings

In all, 80 bedrock features (bedding, schistosity, jointing, and other layering) have been observed in the rocks of the Brunswick vicinity to date. Key findings are presented in the sections below.

3.1 Size and Orientation of Major Linear Bedrock Depressions

Significant linear bedrock depressions were found, oriented NNE and NE. These depressions range in size from 50-130 feet in width and 5-20 ft. in-depth.

3.2 Steep West-Facing Bedrock Slopes

Most NNE oriented bedrock rises in the EOD range have steep western slopes. Eastern slopes are predominantly gentle, although exceptions do exist. The steeper western slopes of bedrock rises can consist of a series of small (4-5 feet) terraced outcrops (Figure 1), or larger individual cliffs (15-18 feet or more above overburden) (Figure 2). Some of these slopes are associated with significant pegmatite sills. The largest of the pegmatite sills is approximately 10 to 12 feet wide, 600 ft. long and ranges in height 4 to 8 feet above the EOD pond (Figure 3).

3.3 Site 11 Bedrock Peak

Considerable evidence now suggests that the bedrock peak at Site 11 is in fact a NNE oriented ridge with a steeper western face. Such a feature may or may not include a pegmatite sill.

3.4 Pegmatite/Meta-Volcanic Rock near CL-1

A major pegmatite outcrop resides within 400 ft of the 8+ mile lineament, CL-1 (Figure 4). (CL-1 is the primary NNE lineament with the most consistent supporting evidence over its 8+ mile length. It extends to the North in the deepest part of the bedrock trough between EW-5A and MW-305.) This West-facing pegmatite cliff has far more micro-aperture fracturing than other EOD outcrops. Furthermore, a meta-volcanic chlorite schist was discovered at the base of this outcrop. Such rock is uncommon in the area, although not unheard of. The local geologic/hydrogeologic significance of these features is unknown at this time.

3.5 Schistosity and Fracturing

Schistosity and jointing (fracturing) are the most significant of the observed bedrock features for conceptualizing possible bedrock/overburden groundwater interactions. The variations of these characteristics by rock type are presented in Figure 5.

3.5.1 Cape Elizabeth Schistosity

Figure 5A depicts the schistosity of the Cape Elizabeth Formation. This rose/pole diagram reveals a strict NNE orientation, steeply dipping to the ESE. (Note that pole plots are somewhat non-intuitive. A fracture dip to the ESE appears as a point in the WNW quadrant of the compass.) Consequently, West-facing slopes of Cape Elizabeth rock that are sufficiently steep and high enough to rise above the Presumpscot clay may make good hydraulic contact with overburden formations. This observation applies both

to the Site 11 bedrock peak, and to the (West-facing) East wall of the NNE bedrock trough, especially between EW-5A and MW-305.

3.5.2 Cape Elizabeth Joints

Figure 5B depicts 32 joints observed in the Cape Elizabeth Formation. These joints are most frequently oriented WNW, dipping steeply to the SSW or NNE. If steep, near vertical fractures such as these exist at the Site 11 bedrock peak, they could provide overburden flow entry into or through the peak/NNE ridge. A cluster of sub-horizontal sheeting joints can be seen as well in the pole plot.

3.5.3 Pegmatite Joints

Figure 5C depicts 14 joints observed in the pegmatite structures. As volcanic intrusions, these rocks have very different fracturing patterns than the meta-sedimentary Cape Elizabeth Formation. 13 of these joints are steeply dipping. Roughly a third of the joints are oriented NW or NNW, commonly dipping to the SW. The remainder of the joints cover a wide variety of NE and ENE orientations, dipping both to NW and SSE. Consequently, if the Site 11 bedrock peak is a NNE ridge encompassing a pegmatite sill, the sill may serve to impede horizontal and vertical groundwater flow more than a wholly CE ridge might. However, this is not definitive.

3.5.4 All Bedrock Features

Figure 5D depicts the strike and dip of all 80 bedrock observations. Bedding planes combine with Cape Elizabeth schistosity to create a predominant NNE strike orientation in this diagram. The major WNW rose-petals are comprised primarily of Cape Elizabeth joints. The orientation-influence of the pegmatite is largely lost when looking at this combined perspective. Regarding dip angles, very few features were observed in interval 15-65 degrees.

3.6 Fracture Correlation of Lineaments

Of the lineaments delineated in the vicinity of Site 11 for the workplan, those oriented NNE and WNW correlate well to observed Cape Elizabeth Formation schistosity and joints. Consequently, 7 of 9 lineaments near Site 11 can be considered fracture-correlated (Figures 5 and 6). In addition, a small set of EOD fractures does correlate to N50E, suggesting a possible physical reality for the two NE oriented lineaments; However, further fieldwork is required to demonstrate this. There was no significant fracture correlation to the NW in the CE, suggesting that NW lineaments such as the Mere Brook valley linear (not depicted) may not be fracture-related.

3.7 Bedrock Hydraulic Conductivity

Given the consistent, steeply dipping fractures noted both in CE and pegmatite outcrops, it is likely that many bedrock areas will register greater vertical than horizontal hydraulic conductivity. Exceptions to this would include flow directly along fracture zone strikes or areas of horizontal sheeting. In overburden, the vertical hydraulic conductivity is often an order of magnitude or more less than horizontal conductivity.

4.0 Ramifications for the Geophysical Investigation

These observations suggest several modifcations that could be made to the proposed geophysical investigation.

- Greater effort could be focused on investigating ***both*** eastern and western slopes of the Site 11 bedrock peak, especially to seek out steep West-facing slopes.

- Overburden stratigraphy at Site 11 could be determined to the extent possible, especially in areas of steep western slope.

- The possibility of a pegmatite sill and contact joints could be evaluated at Site 11.

- The possibility of cross-peak/ridge fractures could be evaluated

- The possibility of steep West-facing slopes, pegmatite sills, and fracture zones in the deepest part of the bedrock trough near EW-5A and MW-305 should be evaluated.

These suggestions will be incorporated into the investigations as funding permits.

5.0 Further Fieldwork

As mentioned earlier, further fieldwork is planned in conjunction with Dr. Hussey to:

- Capture the fracturing of East-facing slopes (since such bedrock slopes are known to directly contact sand at Site 11).

- Further examine rock composition and fracturing near CL-1, to evaluate the possible hydrogeologic significance of this lineament.

- Ensure that sample density is sufficient to capture both regional and local fracturing (e.g. to further evaluate fracture correlation to NE and NW lineaments).

- Further evaluate the characteristic extent of steep NNE slopes to determine the most cost-effective spacing between parallel cross-ridge seismic/resistivity lines to reasonably detect such features.

Figure 1

Figure 2

Figure 3

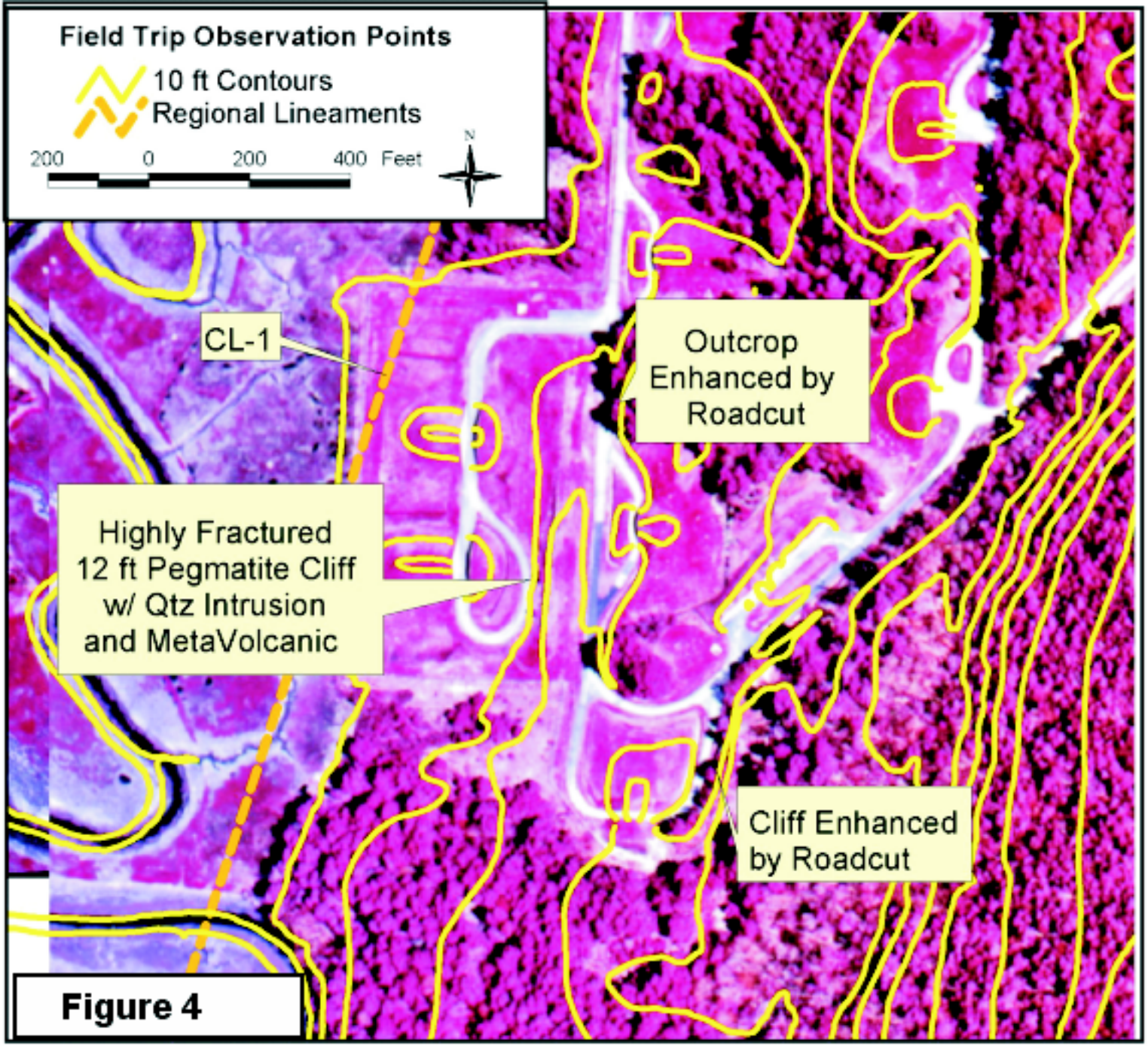
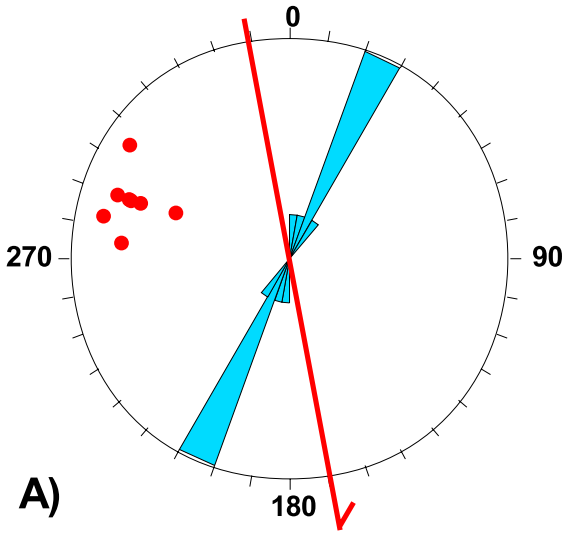


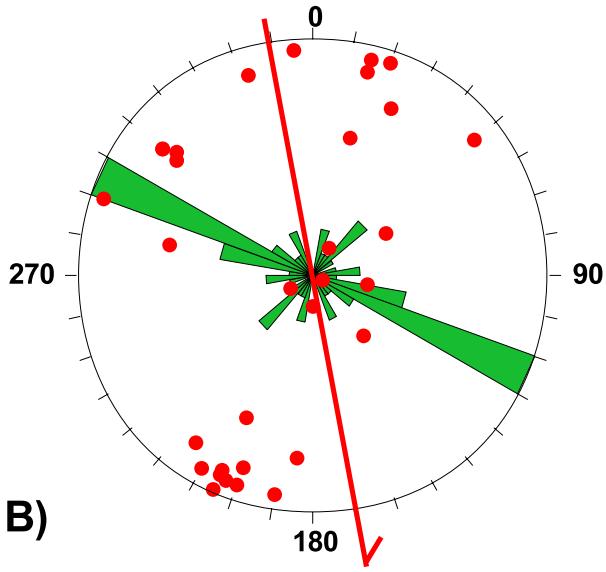
Figure 4

116 D Hussey 120202.apr

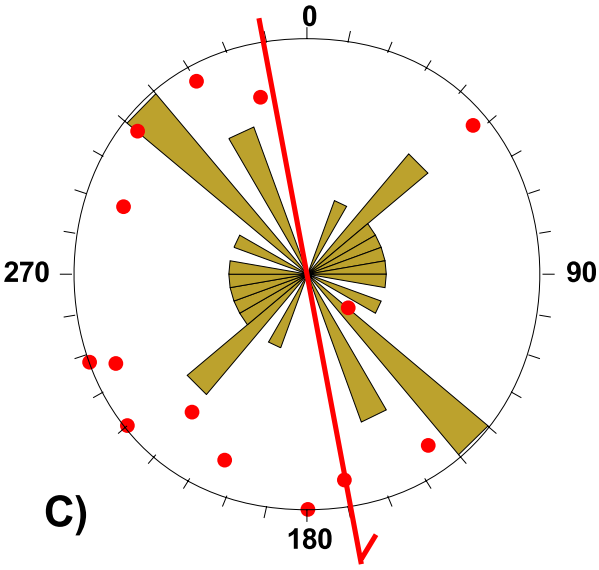
Figures 5A, 5B, 5C, and 5D
Bedrock Features in the Brunswick Area



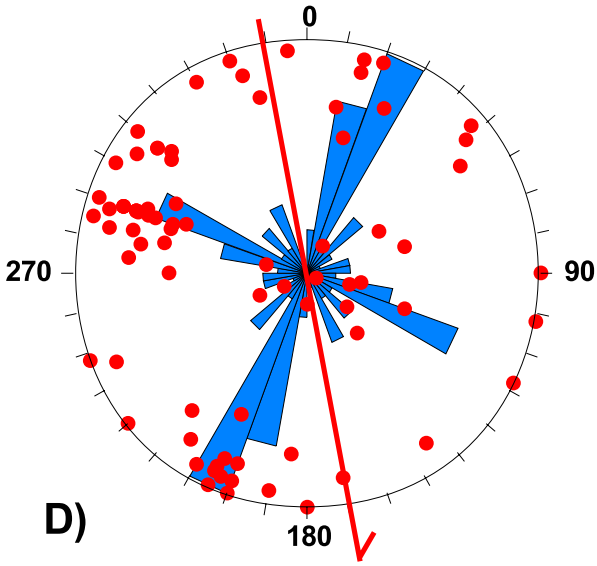
Rose - Cape Elizabeth (CE) Schistosity Strikes n= 8
Pole Plot - Dips of CE Schistosities
Approx. Direction of Glacial Flow



Rose - CE Joint Strikes n= 32
Pole Plot - Dips of CE Joints
Approx. Direction of Glacial Flow



Rose - Pegmatite Joint Strikes n= 14
Pole Plot - Dips of Pegmatite Joints
Approx. Direction of Glacial Flow



Rose - Strikes of All Bedrock Features (includes bedding, etc.) n= 80
Pole Plot - Dips of All Bedrock Features
Approx. Direction of Glacial Flow

Rose Diagram: A relative frequency histogram. The size of each rose petal indicates the relative frequency of strikes within the given 10 degree bin, in proportion to the frequency of the bin having the greatest number of strikes.

Pole Plot Explanation: Each red point represents the intersection point between a lower hemisphere of the compass and a perpendicular pole projecting from the joint plane at the compass center. Therefore, features oriented NNE (as in 1A) and steeply dipping to the ESE have points plotting close to the compass circle-edge in the WNW.

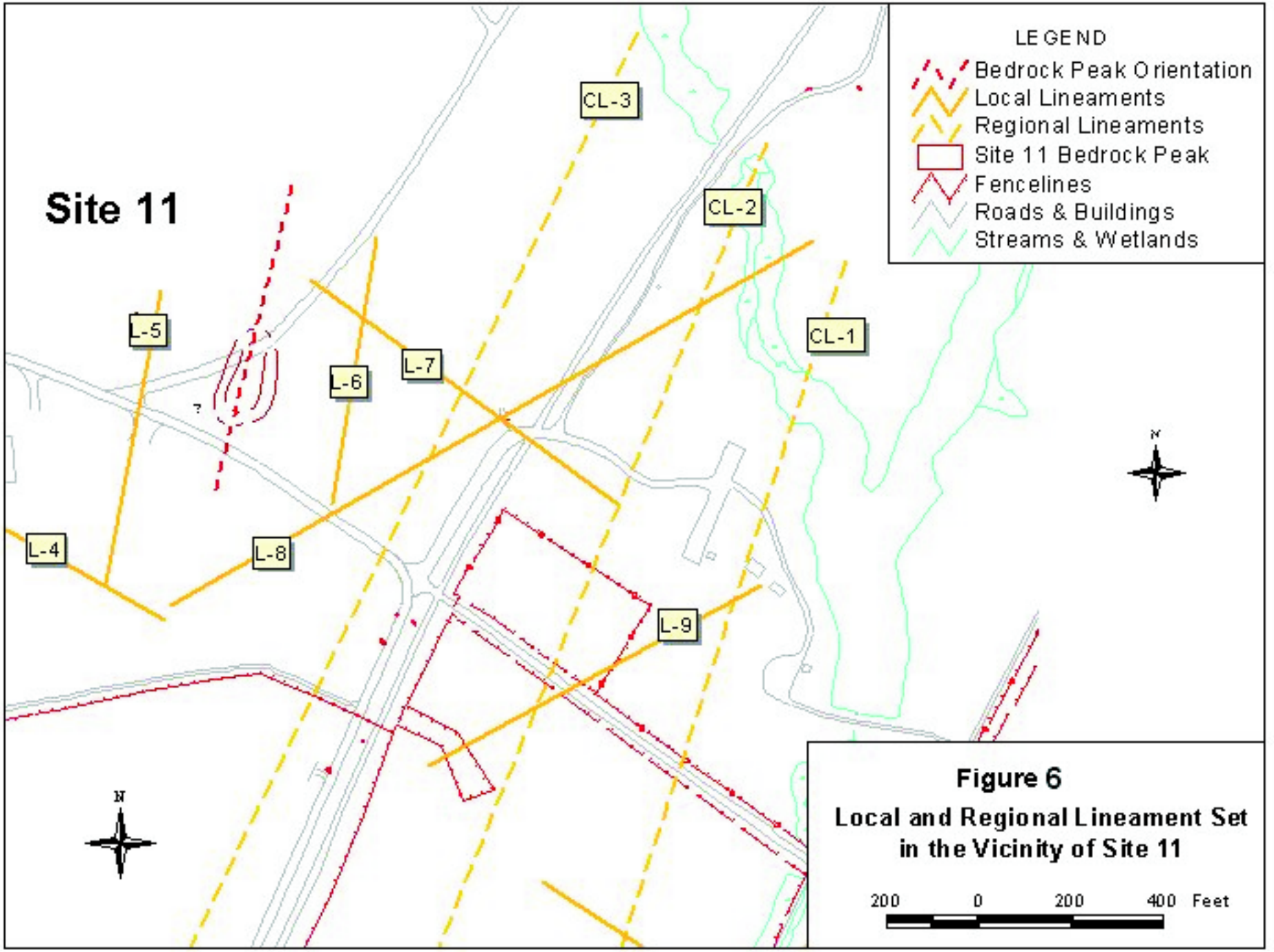


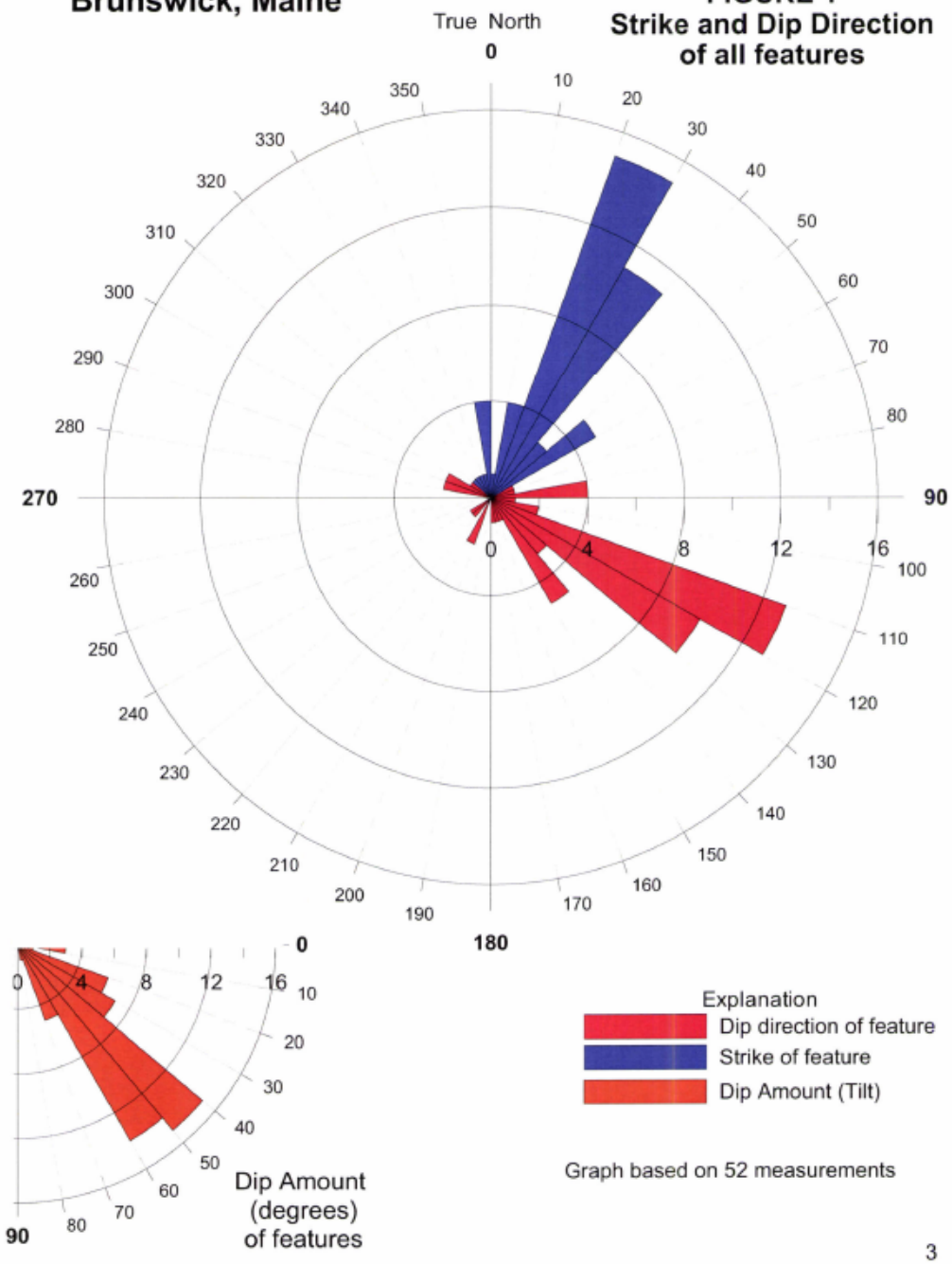
Figure 6

Local and Regional Lineament Set in the Vicinity of Site 11

116 Site 11 Lineaments.apr

NASB Eastern Plume Site
Brunswick, Maine

FIGURE 1
Strike and Dip Direction of all features



Graph based on 52 measurements

DISCUSSION ITEMS AND DECISIONS
SITE VISIT
NAS BRUNSWICK SITE 12 & QUARRY
NOVEMBER 4, 2011

Attendees:

Navy: Bob Leclerc NASB Public Works)

MEDEP: Chris Evans, Claudia Sait

EPA: Mike Daly, Bill Brandon

Tetra Tech: Syd Rodgers, Chuck Race

<u>Site 12</u>

Discussion Items:

1) Background Items Discussed included:
    a. Objective of groundwater investigation is to determine if there are impacts to groundwater.
    b. Scope of groundwater investigation included bedrock fracture trace analysis an very low frequency (VLF) survey to locate water bearing fractures in bedrock and use that information to locate three monitoring wells.
    c. EPA 2003 bedrock study of Site 11 and Site 12.
2) Site Walk Observations included:
    a. Mostly quartz-feldspar-mica schist (Cape Elizabeth Formation) with pegmatite intrusions outcroppings on east and west sides of present/historic berms and east of pond.
    b. Predominant north to northeast direction of bedrock ridges, fractures, and foliation. Fractures dip steeply to the southeast.
    c. Secondary west-northwest fractures.
    d. High angle fractures cross cut west-facing escarpment on east side of pond.
    e. Present and previous berms are within or along the east flank of an apparent shallow basin.
    f. Present berm surrounded on north, east and west by wetlands.
    g. Pond on east side blocked on southeast end beneath dirt road may back flow into basin on north end.
    h. Surface water drainage out of basin to west and north between bedrock ridges.
3) EC. Jordan Findings Discussed included:
    a. 3 test pits found several feet of fine grained materials on top of bedrock at present berm location. No explosives constituents found.
    b. No groundwater samples.
    c. Confirmed bedrock shallow beneath present berm.
4) Unknowns Discussed included:
    a. Is soil and shallow groundwater impacted from munitions activities?
    b. Groundwater flow directions in shallow system?
    c. Groundwater flow directions in deep system?
5) Surface Geophysical Techniques discussed included:

a. Low Frequency Ground Penetrating Radar (GPR) at another site with similar geology identified overburden thickness, depth to groundwater, subhorizontal sheeting fractures that may transport groundwater in shallow bedrock.
b. Very Low Frequency (VLF) – may target deeper fractures in deeper bedrock.

Decisions:

1) Perform fracture trace analysis to better characterize fracture orientations in outcrops surrounding the site. Collect additional site specific bedrock fracture data as needed to complement previous bedrock fracture mapping.
2) Consider Low Frequency GPR and VLF to gain a more complete understanding of potential shallow and deep groundwater migration pathways.
3) Based on geophysical results and locations of berms, select three shallow well locations.
4) If groundwater in shallow overburden, complete well in that zone; otherwise complete well in shallow bedrock.
5) If field work conducted this fall, consider munitions leader (Syd Rodgers) available through Thanksgiving. Combine fracture trace analysis and geophysical survey.

<u>Quarry</u>

Discussion Items:

1) Background:
   a. Previous borrow pit filled with junk.
   b. Rock face blasted. Blasted rock may have been used for road base.
   c. Fence to be placed around the Quarry. Construction starts 11/7/11.
2) Site Walkover Observations.
   a. Concrete, rebar, metal grate, drum, scissors, cable, brick, bicycle rack observed near blasted rock face on south east side.
   b. Bedrock –multiple intersecting fracture sets giving rise to blocky blast rock tailings.
   c. Surface water in depression on southeast side of pit.
3) Unknowns:
   a. Depth of quarry is unknown, but probably deep enough for shallow overburden wells.
   b. Depth to groundwater, although presumed shallow.
   c. Is soil and shallow groundwater impacted?

Decisions:

1) Since it is unknown soil or shallow groundwater impacts exist, it is premature to conduct bedrock drilling.
2) If bedrock drilling is required, bedrock fracture trace analysis would be useful.

DISCUSSION ITEMS AND DECISIONS
SITE VISIT
NAS BRUNSWICK SITE 12 & QUARRY
NOVEMBER 4, 2011

To Do List:

1) MEDEP to provide topographic contour map of Site 12 area (2-ft contour interval).
2) EPA to provide disk with photographs.
3) Tetra Tech to consider both low frequency GPR and VLF geophysical techniques.

VISUAL SITE INSPECTION

Former NASB REC-7 & EDC-13 Parcels

Visual Site Inspection with Navy, MEDEP and EPA

05/01/12

Navy Personnel: Paul Burgio

MEDEP Personnel: Claudia Sait, Chris Evans

EPA Personnel: Mike Daly

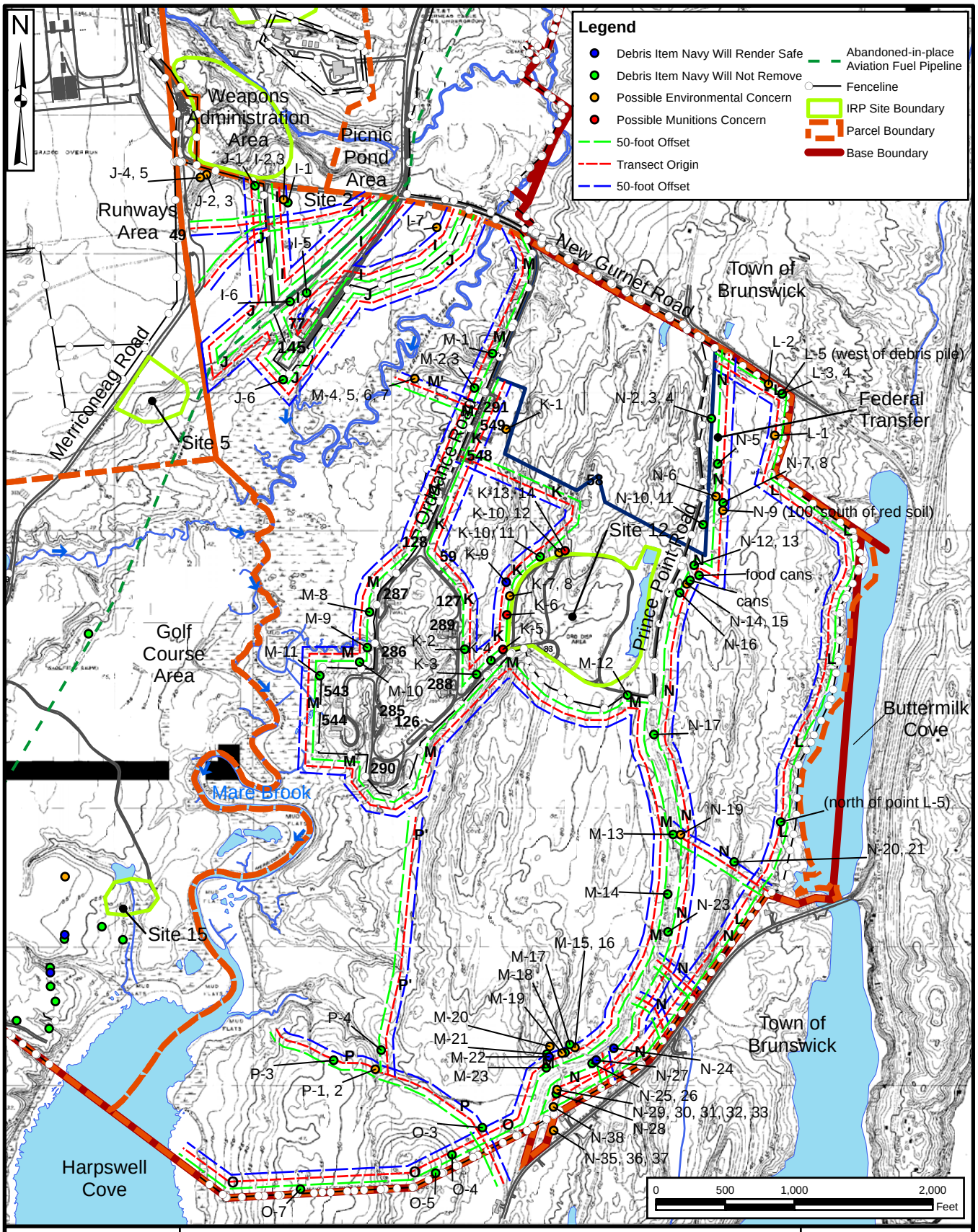
Tetra Tech Personnel: Brian Geringer, Steve Giannino

0900: Arrive at Building 53 CSO Caretaker office (Building 53), discuss planned activities with Navy, MEDEP, EPA and Town of Brunswick representatives and perform tailgate Health and Safety Briefing.

1015: Begin VSI discussing path forward at each area of concern

Area	Path Forward
J-2, 3, 4, 5	Remove drum carcasses, perform surface geophysics, possible test pitting if additional anomalies are discovered, soil/groundwater sampling for VOCs using DPT rig.
I-2, 3	Perform soil and groundwater sampling for VOCs using DPT rig, possibly collect sample of water in wet well, cap pipe to alleviate hazard.
I-7	Collect soil sample beneath drum for EPH and PCB analysis, use schonstedt to verify no additional buried metal is present.
I-1	Debris pile, no action needed.
M-4, 5, 6, 7	Remove metal cans, drums and debris, perform geophysics, possible test pitting of anomalies, advance soil borings, collect groundwater and soil samples using DPT rig.
M-1	Car fender, no further action
K-1	Two 5-gallon containers, no further action
K-7, 8	No further action, possible MEC item flagged (looked at by UXO technician, deemed as not munitions related).
K-9	No further action

K-12	Sample suspected asbestos containing material
K-13	No further action
M-12	Sample as part of Site 12 RI
M-21	No further action
M-22	Well, fill in with soil (to 1' below grade) to reduce physical hazard. On 5/3 Town of Brunswick asked to hold off until their archaeological expert can review.
L-2, 3, 4, 5	No further action
N-5, 7, 8	No further action
N-9	No further action
N-14, 15	No further action
N-24	Well, fill in with soil (to 1' below grade) to reduce physical hazard. On 5/3 Town of Brunswick asked to hold off until their archaeological expert can review.
N-29 to 33	Remove metal debris, visually inspect/screen soil beneath debris with PID.
N-35, 36, 37	Collected VOC soil sample beneath each drum and collect one composite soil sample for EPH and Metals. Collect sample of one drum contents.
N-38	No further action
D-1	No further action
Site 15 Dam	No further action



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TETRA TECH

VISUAL SITE INSPECTION, APRIL 2012
TRANSECTS I,I',J,J',K,L,M,M',N,N',O,P,P'
WITH 1957 TOPOGRAPHY
FORMER NAVAL AIR STATION BRUNSWICK
BRUNSWICK, MAINE

SCALE	AS NOTED
FILE	\..\NASB_PARCEL_12D _TRANSECT_1957_POST.MXD
REV	0
DATE	04/16/12
FIGURE NUMBER	POST VSI-EAST